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ABSTRACT

The purposes of this metric handbook are: (1) to help teachers understand the general principles of measurement instruction; (2) to help teachers understand how children develop measuring concepts; (3) to provide information that will help teachers learn to use SI metrics; (4) to provide examples of learning experiences that teachers can use with learners; (5) to help teachers integrate metric instruction into the existing curriculum through an interdisciplinary approach so that it does not become an isolated topic; (6) to provide teachers with information about sources of materials needed to supplement textbooks already in use; and (7) to provide administrators and teachers with suggested procedures for implementing metric instruction. Chapter topics include historical developments, using metric units, developing measurement concepts, measurement learning activities, and administrative implications and recommendations. (MP)

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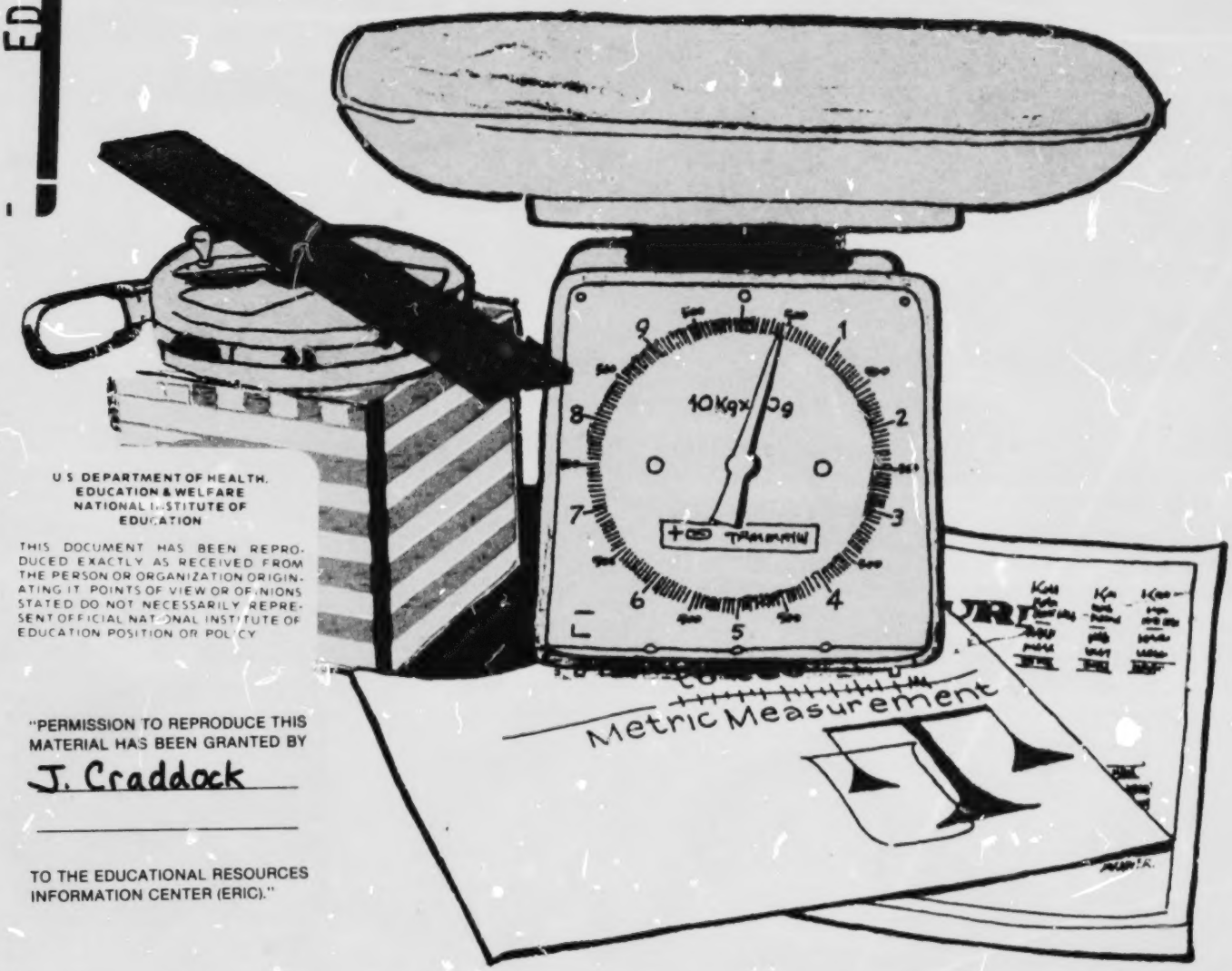
Metric Measurement

A Handbook for Elementary Teachers and Administrators



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1977

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Metric Measurement

A Handbook for Elementary Teachers and Administrators

Prepared by

A committee of Oklahoma Educators

in cooperation with the

Oklahoma State Department of Education

Leslie Fisher

State Superintendent of Public Instruction

Division of Instruction

J. D. Giddens, Assistant Superintendent

FOREWORD

With the rapid change to the use of the metric system of measurement in the United States, it is imperative that Oklahoma teachers begin now to prepare our students to live in a "metric world." The necessity for business and industry to use metric measurements in order to compete for trade in the world market will continue to affect every citizen of the United States.

As teachers attempt to help students learn to use metric units, the need for learning materials becomes apparent. In response to this need the State Department of Education has undertaken the publication of this handbook.

It is hoped that teachers and administrators will find this publication useful in providing the kind of learning experiences that will be most beneficial for the young people in Oklahoma.

Leslie Fisher
State Superintendent of Public Instruction

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INTRODUCTION

"Let's go swimming today. I hear the temperature will reach 30 degrees. It is only 30 kilometres to the lake and we can be there in 20 minutes if we drive 90 kilometres per hour."

Will the change to the metric system force you to speak like this? Perhaps, but ready or not, America is going metric! After years of discussion our Nation is clearly moving toward conversion to the metric system of measurement. Industrial willingness, international conditions, and educational responsiveness to social change support the movement to metrication. Boys and girls who will live in tomorrow's world must learn to "think metric."

On December 23, 1975, President Gerald Ford signed the Metric Conversion Act of 1975. This historic step finally gives official federal sanction to the change that has been taking place at an accelerating rate in the United States.

The Metric Conversion Act declares "..that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system. The Board shall consist of 17 members, including it's chairman, who shall be appointed by the President, by and with the advice and consent of the Senate. It will have no compulsory powers. It shall be the function of the Board to devise and carry out a broad program of planning, coordination, and public education, consistent with other national policy and interests, with the aim implementing the policy set forth in the Act."

The change to metric measurement requires a general affective change that will not come automatically. The motivational task is a large one. People must appreciate the need for change if they are to accept it. This is the task of education, which also must provide the requisite cognitive knowledge and skill.

For educators, the switch to the metric system offers an opportunity to reexamine the role of measurement in the curriculum. For many years, it has not been considered a vital component. At some levels, it is taught if there is time to include it, but measurement is too necessary to everyday living to be slighted in the curriculum. Change to the metric system offers an opportunity to restructure the teaching of measurement so that its concepts can be developed more meaningfully through activities. Thus, the metric system is not merely memorized and applied without understanding.

The choice of a strategy for teaching the metric system can enhance or impede efforts to get students to "think metric." One of the commonly reported mistakes in teaching metric units is the reliance upon conversion from one system of measurement to another. Experience in countries which have changed to the metric system clearly points to faults in this strategy. Consequently, it is recommended that the conversion process between metric units and "customary" units be minimized. In cases where conversion is necessary, appropriate charts and tables which do not require the use of conversion formulas should be available.

The best way for anyone, child or adult, to become familiar with the metric system is to acquire the habit of thinking in metric terms. This is much easier when familiar objects and quantities are related to commonly used metric units.

The teaching of measurement concepts and skills logically belongs in the mathematics program. However, if students are to truly "think metric," the metric system should be reinforced and applied throughout the total school curriculum.

In order for the teachers to facilitate the development of measuring concepts in learners, it is

important for them to understand how children develop intellectually as well as to have adequate knowledge of the mathematical concepts of measurement and how the metric system works. It is also important for the teacher to have a clear understanding of his/her role and the learner's role in a child-centered, "hands-on" activity approach to learning.

The evidence is clear that teachers and administrators have an immediate need for assistance in integrating metric measurement in the school curriculum. This publication has been prepared to meet that need.

The purposes of the metric handbook are:

1. to help teachers understand the general principles of measurement instruction;
2. to help teachers understand how children develop measuring concepts;
3. to provide information that will help teachers learn to use SI metrics;
4. to provide examples of learning experiences that teachers can use with learners;
5. to help teachers integrate metric instruction into the existing curriculum through an interdisciplinary approach so that it does not become an isolated topic;
6. to provide teachers information about sources of materials needed to supplement textbooks already in use; and
7. to provide administrators and teachers suggested procedures for implementing metric instruction.

Chapter 1

HISTORICAL DEVELOPMENTS

Measurement Systems in General

The human race has needed and developed tools for measuring since the beginning of civilization. Such rudimentary devices as parts of the body, plant seeds, and the distance from a certain king's nose to the end of his arm have been used for units of measure. Many of these units are still used. For example, horses are measured by how many "hands" high they are. One basis for the inch was the distance determined by three barleycorns laid end-to-end.

As civilization developed and society became more complex, more sophisticated measuring devices became necessary. Eventually, more efficient measuring techniques did evolve. They evolved, unfortunately, wherever there was a need for them, and very little uniformity was the result.

The lack of uniformity is not surprising during the early stages of development of a system of measure, since trade between nations, trade between provinces within nations, and even trade between adjoining counties or townships was limited. Communication methods were primitive and slow communication further restricted the development of a uniform system of weights and measures. The need for a uniform system or some type of standardization of units became evident as man became more mobile and as interstate and international commerce developed. (For a detailed history of the development of standard units of measure, consult the references in the appendixes.)

Development of a Measuring System in the United States

Progress toward a uniform system of weights and measures in the United States was motivated by the adoption of the Constitution. Power was awarded to the Congress "to coin money...and fix standards for weights and measures." Soon after the adoption of the Constitution, Thomas Jefferson and Robert Morris developed and proposed a coinage system that was adopted. The dollar was the basic monetary unit. So that parts and multiples of the dollar would be easily calculated, the decimal system was favored and approved for determining smaller and larger units of money. Thus in 1792, the United States monetary system was established and those basic units of money still serve us today.

Jefferson was not so fortunate in gaining adoption of the system of weights and measures that he had spent so many years developing. His proposal for measures had features similar to the monetary system. An invariable standard (base unit) was needed in the major categories of measurement, and Jefferson chose a cylindrical iron rod as the standard for linear measure. The length of the rod was determined by the principle of the period of a simple pendulum. The rod was to be of a length such that one complete arc, over and back again, would require two seconds. This rod turned out to be about 58 inches in length. The rod was to be subdivided into five equal parts and each part was to be called a "foot." Each foot was then to be subdivided into **ten** equal parts and these were to be called "inches." More subdivisions and multiples of the foot were proposed with all based on decimal calculations.

The other categories of weights and measures were developed in a similar fashion. A cubic inch of rainwater was to be the basic unit of "weight" and was called an ounce. A pound was to be ten ounces. Of prime importance, however, multiples and subdivisions of all the units were based on powers of ten.

Jefferson's plan involved three extremely important principles of any measuring system. First, the units would be based on an unchanging standard found in the physical world; second, the length, volume, and weight would be interrelated; and third, the subdivisions and multiples of each unit would be based on the decimal system of numeration.

Jefferson's plan was considered by Congress for six years, but no laws were passed to support the

system. Some historians think that the divisions of the foot and the pound into ten parts exerted a deterring influence on Congress. Perhaps another reason was a new system of measurement that was being studied in Europe.

In 1790, the Royal Society of London was asked to join with the Academy of Science of Paris to design a measurement system. Of special note was the fact that this proposed system would be based on the three principles that had been the distinguishing characteristics of Jefferson's plan for the United States.

The French Academy shortly developed what has become the metric system. The metre was designated as the basic unit of length and was defined to be equal to one ten-millionth of the arc of a meridian of longitude from the equator to the noth pole. A litre was the basic unit of capacity and was described as the capacity of a container whose volume was equal to that of a cubic decimetre. The gram was the basic unit of mass and was defined to be the mass of a cubic centimetre of distilled water at four degrees Celsius. In each category, a system of prefixes (see Chapter 2) was adopted to indicate subdivisions and multiples of each of the basic units. Again, it should be noted that Jefferson's ideas were adopted wholesale in this new system and that this fact gives an American flavor to what has been considered a foreign development.

In the years since Jefferson first proposed his system of weights and measures to Congress, many other attempts have been made to encourage adoption of a system based on his three principles. The adoption of the metric system was urged by various scientific societies so that some uniformity in the world commerce would be achieved. In 1795, copies of the metric units were sent by France to the United States Government. Congress took no action.

In 1816, President Madison reminded Congress that the United States still had not made provision for a uniform system of weights and measures. Madison's Secretary of State, John Quincy Adams, was assigned the task of preparing a new report on the situation. Adams issued, in 1821, a comprehensive report entitled **The Report Upon Weights and Measures** which listed both advantages and disadvantages of the English and Metric systems. Proponents of both systems used the **Report** as a basis of support for their system. Consequently, Congress took no action at all on the uniformity question.

In the period from 1830 to 1856, various governmental agencies, together with some Congressional action, finally directed that the yard, the avoirdupois pound, and the Winchester bushel would be official units of measure. Congress provided complete sets of these standards to all states and territories with each state and territory adopting the standards. Finally, some degree of uniformity had been secured in the United States!

However, interest in the metric system did not subside. During the next thirty to forty years the United States joined with sixteen other nations in signing the **Treaty of the Metre**. Hence the first international system of weights and measures was adopted. The Convention of the Metre, in 1875, established an International Bureau of Weights and Measures, an International Committee of Weights and Measures, and an International General Conference on Weights and Measures. In 1890, the United States received the international prototypes of the metric units, and in 1893 these prototypes became the **official bases** for the yard and the pound. That is, the yard and pound were defined in terms of the metre and the kilogram. This means that United States measures have had metric bases since 1893.

In 1948, the General Conference on Weights and Measures was requested to make recommendations on a single system of metric units that would be suitable for adoption by all countries adhering to the Convention of the Metre. The name for the chosen system of units, which was adopted in 1960 by the General Conference, was the International System of Units (SI).

Further attempts were made to adopt the metric system as our only legal measuring system but failed. However, in 1959, Congress created a Committee on Science and Astronautics and this committee

subsequently officially defined all the English units in terms of metric units. In 1968, Congress directed the Secretary of Commerce to start the U. S. Metric Study. This report was completed and delivered to Congress in 1971. The report recommended that the United States change to the International System of Units deliberately and carefully. For various reasons, Congress failed to approve this recommendation.

Recognizing the growing number of businesses and industries committed to metric changeover and the importance of preparing American children to use the metric system, Congress, in 1974, included a section in Public Law 93-380 (Revision of the Elementary and Secondary Education Act of 1965) that obligated the U. S. Office of Education to make provisions for metric education. Then on December 23, 1975, President Gerald Ford signed the **Metric Conversion Act of 1975** and that act became Public Law 94-164. This act authorized the President to appoint a seventeen member Metric Conversion Board with responsibility for regulating the voluntary conversion to the metric system within the United States.

As the metrication process continues, educators can be relied on to do some of the fundamental work necessary for the change --that is, provide training opportunities for the general public as well as the school children of the nation. This educational responsibility is exciting and challenging.

Chapter 2

USING METRIC UNITS

In the International System (SI), there are seven base units along with several derived and supplementary units. Only the most commonly used units will be discussed here. Formal definitions and complete lists of base units along with supplementary and derived units are given in National Bureau of Standards Special Publication 330. A summary of SI units, prefixes, and symbols is given in Appendix E.

Not all objects can be measured accurately and efficiently with a base unit. Multiples and submultiples exist and are obtained by multiplying or dividing the base unit by powers of ten. Thus, the decimal system and place value structure are the foundation of the metric system of measurement.

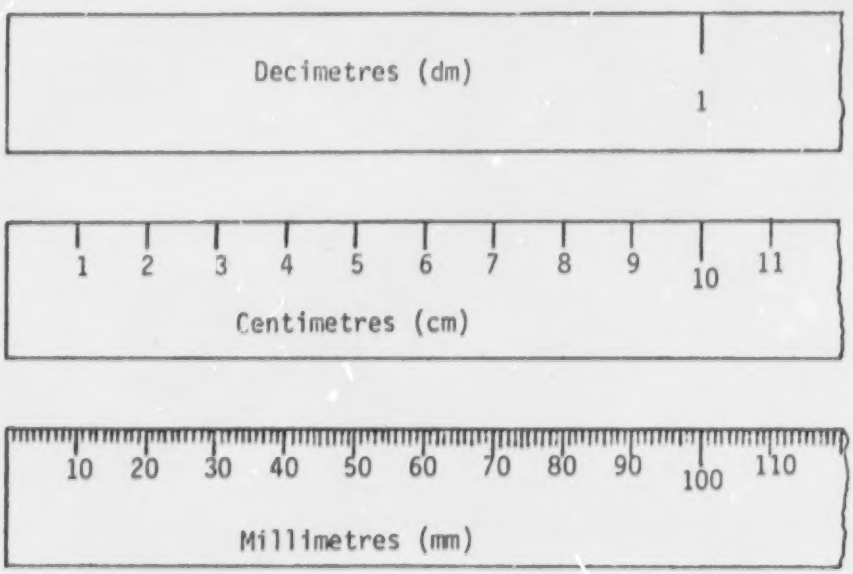
Prefixes are used to identify these multiples and submultiples. Notice how the submultiples parallel our monetary system where one dollar is used at the unit: "deci" relates to the dime and means one tenth of the unit, "centi" relates to the cent and means one hundredth of the unit; and "milli" relates to the mill and means one thousandth of the unit.

For multiples of the unit, "deka" means ten times the unit, "hecto" means one hundred times the unit, and "kilo" means one thousand times the unit.

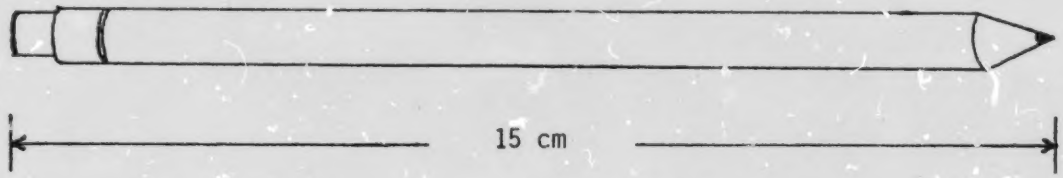
LENGTH

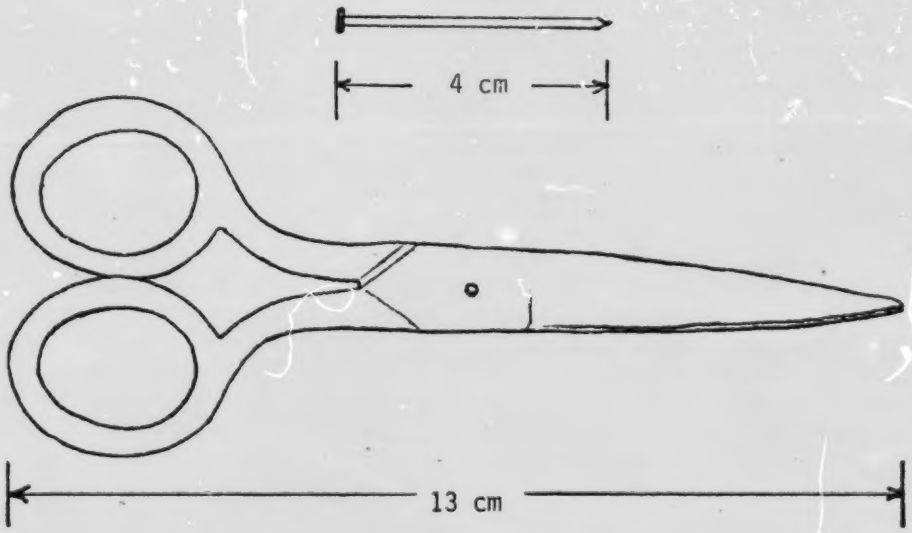
The metre has been established as the base unit of length. It is approximately the distance from the floor to a door knob or from the floor to the belt of an average sized man. Room dimensions, track and field events, and other intermediate lengths use the metre.

When the metre is too large, a decimetre (one tenth of a metre), a centimetre (one hundreth of a metre), or a millimetre (one thousandth of a metre) can be used. Although the decimetre exists, it is rarely used in "everyday practice." The relationships between decimetre, centimetre, and millimetre and illustrated below.

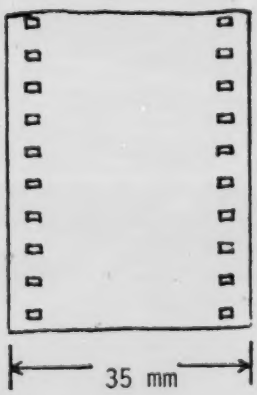


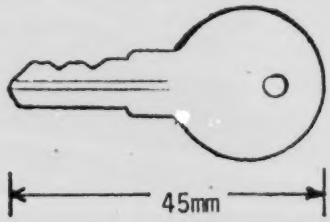
The centimetre (one hundredth of a metre) is approximately the width of a paper clip and used extensively. Clothing, a person's height, curtains, baking dishes, bed sheets, doors, windows, automobile wheelbase, notebook paper, and other small items are measured using this unit.

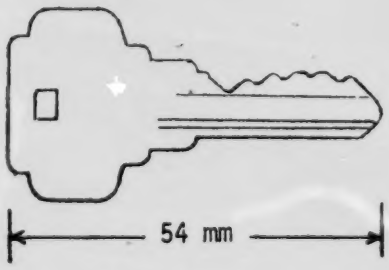




For very small items such as bolts, screws, thickness of coins, plywood, and paneling, the millimetre (one thousandth of a metre) is used. A millimetre is about the thickness of a dime.







Like the decimetre, the dekametre (ten metres) and the hectometre (one hundred metres) are rarely used. Cross country track events, marathons, and distances between towns are measured in kilometres (one thousand metres). One kilometre is approximately seven city blocks in length or eleven football fields from goal line to goal line.

Table 1 summarizes the use of prefixes and appropriate symbols associated with linear measure.

TABLE 1

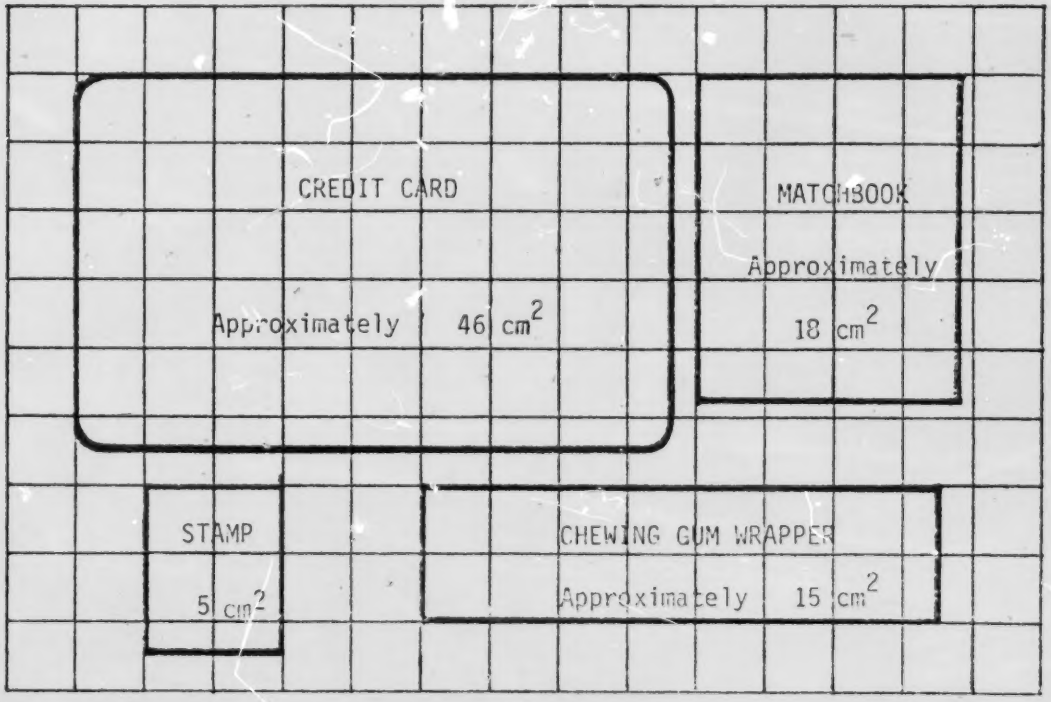
SI Units of Length

Relation to the Metre	Name	Symbol
1000 m	kilometre*	km
100 m	hectometre	hm
10 m	dekametre	dam
1 m	metre*	m
0.1 m	decimetre	dm
0.01 m	centimetre*	cm
0.001 m	Millimetre*	mm

*Most commonly used.

AREA

Area is a measure of a region. In SI, it is expressed as the square of linear units such as square centimetres (cm^2), square metres (m^2), square kilometres (km^2), etc.



The region bounded by a square one metre on each side contains an area of one square metre. Floor space and carpets are measured using this unit. Smaller regions such as notebook paper, posters, and table tops are measured in square centimetres. The area of Oklahoma or the United States is measured in square kilometres.

Measurement of land utilizes another area unit, the hectare. The hectare (h) is equivalent to 10 000 m^2.

VOLUME

Volume is defined as the amount of space occupied by a quantity of matter. It is represented by the cube of linear measure such as cubic centimetre (cm^3) or cubic metre (m^3).

One cubic centimetre is about the space occupied by a sugar cube and is used in measuring small boxes and containers. For rooms and grain bins, the cubic metre is used. One cubic metre is slightly larger than the space occupied by a washer or dryer.

CAPACITY

Although "capacity" is not one of the official SI quantities, it is an acceptable term to be used in conjunction with SI units. The standard measure of capacity is the litre (*l*) which is defined to be one cubic decimetre. One cubic decimetre (dm^3) is the volume of a 10 cm X 10 cm X 10 cm cube (1 dm^3 = 1000 cm^3). This unit is used to measure milk, gasoline, paint etc.

For smaller amounts the millilitre (*ml*) is used. Since 1 m =0.001 *l* and 1 *l*=1000 cm^3, 1 *ml*=1 cm^3. Items such as medication, soft drinks, and many ingredients in recipes are measured in millilitres.

Table 2 summarizes the use of prefixes and appropriate symbols associated with capacity.

TABLE 2

SI Units of Capacity

Relation to the Litre	Name	Symbol
1000 *l*	kilolitre	k*l*
100 *l*	hectolitre	h*l*
10 *l*	dekalitre	da*l*
1 *l*	litre*	*l*
0.1 *l*	decilitre	d*l*
0.01 *l*	centilitre	c*l*
0.001 *l*	millilitre*	m*l*

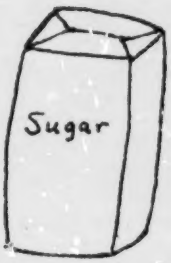
*Most commonly used.

MASS

The SI system uses the kilogram as the base unit of mass. It is approximately the same as the mass of nine sticks of butter and is used to measure the mass of potatoes, sugar, and flour, as well as the body mass of people. The kilogram is the only base unit in SI that uses a prefix. An interesting relation exists in that one kilogram is the approximate mass of one litre of water.

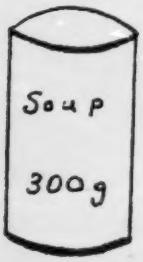
1 kg

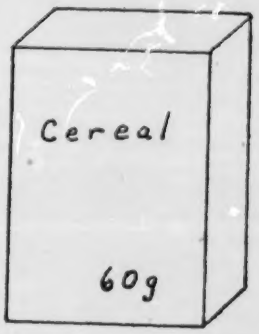
45 kg



2 kg

For measuring small quantities such as canned goods, cereals, and mail the gram is used. Its mass is about the same as a paper clip.





125 g

These two units of mass are the most commonly used. However, the hectogram, dekagram, decigram, centigram, and milligram do exist in SI and are used in specialized fields.

Table 3 summarizes the use of prefixes and appropriate symbols associated with mass.

TABLE 3

SI Units of Mass

Relation to the Gram	Name	Symbol
1000 g	kilogram	kg
100 g	hectogram	hg
10 g	dekagram	dag
1 g	gram*	g
0.1 g	decigram	dg
0.01 g	centigram	cg
0.001 g	milligram	mg

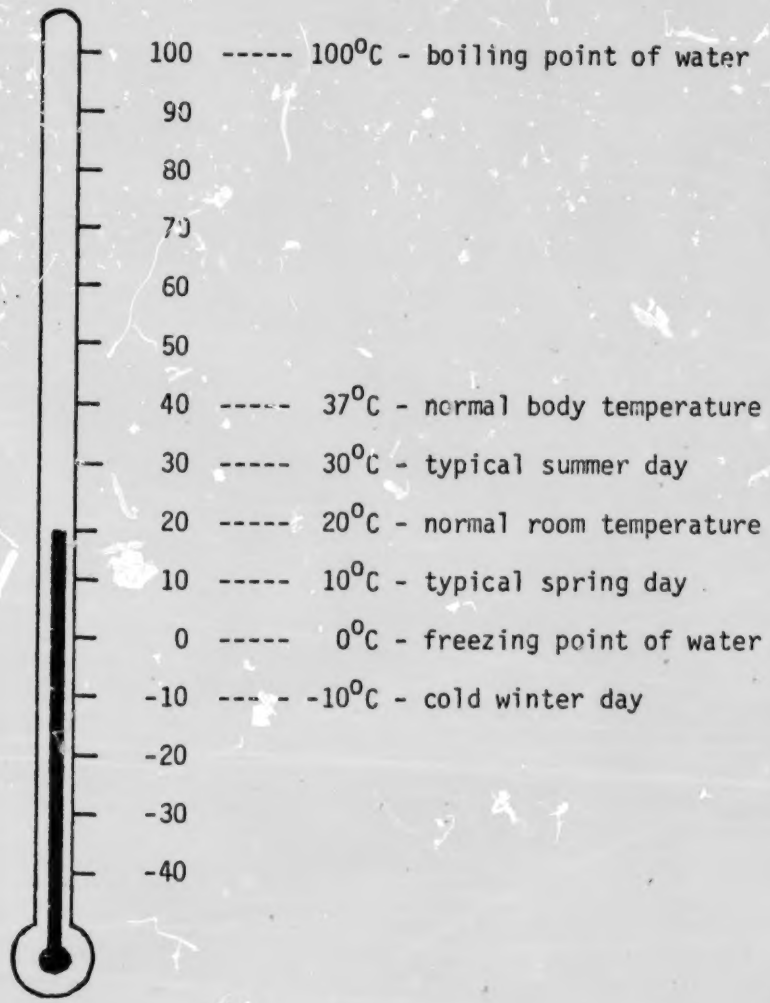
*Most commonly used.

Note: For objects of very large mass the metric tonne (1000 kg) is used. Very small quantities, such as ingredients of medicines, are measured in milligrams.

TEMPERATURE

The Celsius thermometer was named for Anders Celsius (1701-1744), an astronomer and scientist from Sweden, whose idea was to separate the freezing and the boiling points of water with 100 equal parts. For this purpose 0° C is chosen for the freezing point and 100° C for the boiling point of water.

Some common temperature references are given below.



SI Writing Style

The following guidelines are recommended when expressing SI measurements:

1. The spelling of metric terms should be that shown throughout the handbook.
2. Unit names and symbols (except degrees Celsius, °C) are written in lower case letters unless they are used at the beginning of a sentence. (k for kilo)
3. All symbols for numerical prefixes are written in lower case letters except for exa (E), peta (P), tera (T), giga (G), and mega (M).
4. Only one prefix is used at a time with no hyphen between the prefix and the unit. A prefix should never be used alone to express a measurement. (kilogram NOT kilo)
5. When compound units involving division are spelled out, the word "per" is used. (metres per second)
6. Compound symbols formed by dividing units contain a solidus (/) to indicate the division. (m/s)
7. Square unit and cubic unit symbols should be expressed using exponents. ($5\ m^2$ or $5\ m^3$)
8. All abbreviations and symbols are written in singular form; an s is not added for the plural or possessive form. (5 cm NOT 5 cms or 5 cm's)
9. SI unit symbols should not be followed by a period, except at the end of a sentence. (5 cm NOT 5 cm.)
10. Symbols should be used in place of full names when units are used in conjunction with numerals. (5 cm NOT 5 centimetres)
11. A space should be used in place of a comma to indicate groups of three digits to the left and right of the decimal point. (50 000 m, or 0.000 05 m) In numbers of four digits, no space is recommended. (1000 m)
12. A space is left between the last digit of a numeral and the symbol. (5 m)
13. There is no space between the prefix symbol and the unit symbol. (5 cm NOT 5 c m)
14. A zero is placed to the left of the decimal point when the quantity is less than a full unit. (0.5 m)
15. Decimal fractions are preferred to common fractions. (0.5 m NOT ½ m)
16. For simplicity, decimal fractions may often be avoided in common use. (5 mm for 0.5 cm)

Chapter 3

DEVELOPING MEASUREMENT CONCEPTS

Before teachers begin to design instructional activities, some thought must be given to the nature of the population for whom the activities will be developed. Using the space provided below, jot down descriptive words that complete the sentence.

People (children) are by nature. . . . . .

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Among the items listed, there are probably such things as curious, spontaneous, active, "doers" and independent but, at the same time, dependent. If one truly believes that these words characterize the basic nature of children, then what does this say about the types of learning activities that are designed for them? Some of our pedagogical leaders would answer that question with the following:

> Whatever we do in teaching depends upon what we think people are like. The goals we seek; the things we do; the judgments we make; even the experiments we are willing to try, are determined by our beliefs about the nature of man and his capacities.[1]

Measurement instruction is concerned with mental structures and operations with concrete objects as well as with mental images in a way that enhances and depends upon the learner's ability to think. Thinking is affected primarily by the maturation level of each learner and by his/her experiences. The assimilation and accommodation of the brain to actions and objects in the environment fosters the development of the thinking processes. The complex processes of thought are acquired gradually, developing from the simple forms found in the young infant.

What the psychologists have observed is of the greatest importance to teachers in planning the experiences they will offer to children. It is these experiences of making discoveries through his/her own actions and attempting to express what he/she has discovered which enables a child to "think metric" instead of merely carrying out operations mechanically and without real understanding.

Learning activities that are consistent with the nature of children will pose problems that challenge each child to manipulate materials to determine answers. If, in fact, children are active, the learning situations that teachers arrange will capitalize upon this characteristic. When planning measurement

1. *Perceiving, Behaving, Becoming: A New Focus for Education Association for Supervision and Curriculum Development, NEA 1962 Yearbook, Washington, D. C.*

activities, for instance, teachers will have children moving about measuring objects inside the classroom and on the playground. Measurement must be "learned by doing." Children should not be told how to measure; they should be given materials and allowed to experiment and try to solve measurement problems for themselves.

I hear and I forget;
I see and I remember;
I do and I understand.

(Old Chinese Proverb)

The belief that children are naturally curious means that teachers do not have to MAKE children learn, but rather arrange the environment to allow them to make predictions and test hypotheses.

> The study of how children come to measure is particularly interesting because the operations involved in measurement are so concrete that they have their roots in perceptual activity (visual estimates of size, etc.) and at the same time so complex that they are not fully elaborated until somewhere between the ages of eight and eleven.[2]

Consideration must be given to the volumes of substantive research concerning the intellectual development of children compiled by the Swiss psychologist, Jean Piaget. Figure 1 presents a summation of the four stages of intellectual development as posited by Piaget.

The first stage, sensory-motor, lasts from birth to approximately one and one-half years. This stage is characterized by direct action – actions of grasping, looking, sucking, etc. In the latter part of this stage, the child moves from spontaneous movements and reflexes to actions based on an objective or end followed by a search for an appropriate means to that end. This, Piaget characterizes as intelligence. (An act of intelligence is defined here as one in which there is first purpose or end, and then a search for appropriate means to that end.)

Beginning at one and one-half or two years to seven or eight years of age, children are in the preoperational stage. This is typically referred to as the representation or symbolic stage. There is no reversible thought process at this stage. In other words, just because a child knows that 3+2=5, does not necessarily mean that he/she will "know" that 5-2=3. Reversibility in thought comes during the next stage of intellectual development.

Concrete operations (the third stage) extends from seven or eight to eleven or twelve years of age. Most of a child's elementary school years are spent in this stage of developmental thought. This stage is characterized by logical thought processes based in part on the physical manipulation of objects. "Conservation" or "invariance" is a major construct developed during this stage. Piaget uses the term "conservation" to refer to the constancy of a given amount of substance, regardless of how it changes in shape or position. For example, a child is shown two sticks the same length lying side by side. One of the sticks is moved up or down a few centimetres and the child is then asked if the sticks are the same length. When the child understands that the length of the sticks remains the same and rejects what perception tells him/her, he/she is using logic and has arrived at the concrete operational thought level because he/she can "conserve" length.

The fourth developmental level is referred to as formal operations. This stage does not usually occur until eleven or twelve years of age. It is in this stage that the child develops the ability to reason or hypothesize **with symbols or ideas, rather than physical objects as a basis for thinking.**

[2] *Jean Piaget, Barbel Imhelder, and Alina Szeminska. The Child's Conception of Geometry. New York: Basic Books, Inc. 1960, p. vii.*

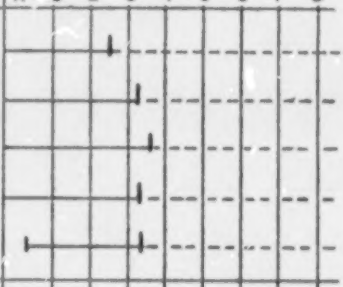
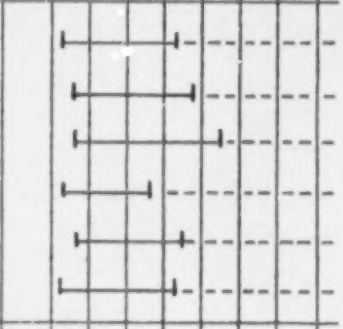
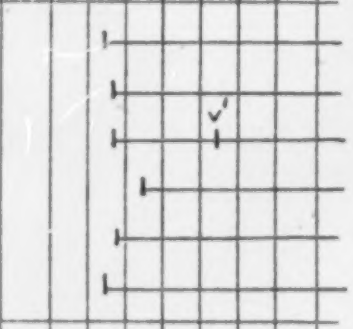
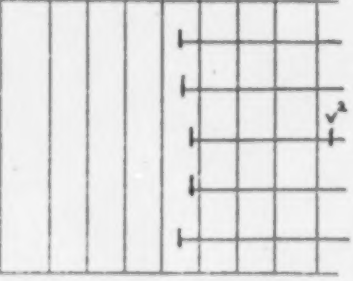
Figure I. Intellectual Developmental Stages--Adapted from the Writings of Piaget and Inhelder, by Odvard Egil Dyrli

Code	Developmental stage	General age range	Characteristics of stage pertaining to problem - solving activities: comments and examples
---	Sensorimotor	Birth to approximately 18 months	--Stage is preverbal --An object "exists" only when in the perceptual field of the child --Hidden objects are located through random physical searching --Practical knowledge is developed which forms the sub-structure of later representational knowledge
A I B	Preoperational or "representational"	18 months to 7-8 years	--Stage marks the beginning of organized language and symbolic function, and as a result, thought and representation develop --The child is perceptually oriented, does not use logical thinking, and therefore cannot reason by implication --The child is simple goal-directed; activity includes crude trial and error corrections --The child lacks the ability to coordinate variables, has difficulty in realizing that an object has several properties, and is commonly satisfied with multiple and contradictory formulations --Since the concept of conservation is not yet developed the child lacks operational reversibility in thought and action
A II B	Concrete operations	7-8 years to 11-12 years	--Thinking is concrete rather than abstract, but the child can now perform elementary logical operations and make elementary groupings of classes and relations (e.g. serial ordering) --The concepts of conservation develop (first of length, next of matter, then of weight and finally of volume) --The concept of reversibility develops, yet inversion and reciprocity are not integrated into a single system --The child is unable to isolate variables and proceeds from step to step in thinking without relating each link to all others

Code	Developmental stage	General age range	Characteristics of stage pertaining to problem - solving activities: comments and examples
A		11-12 years to 14-15 years	--This stage of formal (abstract) thought is marked by the appearance of hypothetical-deductive reasoning based upon the logic of all possible combinations, the development of a combinatorial system and unification of operations into a structured whole. --The INRC group of operations appear (identity, negation, reciprocal and correlative transformations comprising the INRC cognitive structue)
III	Propositional		--The development of the ability to perform controlled experimentation, setting all factors "equal" but one variable (in substage III A, the child's formal logic is superior to his experimental capacity). Individuals discover that factors can be separated by neutralization as well as by exclusion. --Reversal of direction between reality and possibility (variables are hypothesized before experimentation). Individuals discover that a particular factor can be eliminated to analyze its role, or the roles of associated factors --The individual can use interpropositional operations combining porpositions by conjunction, disjunction, negation and implication (all arise in the course of experimental manipulations).
B		14-15 years and onward	

MODEL MEASUREMENT PROGRAM

Figure 2

State of measure/process	Quantity	Grade level: K 1 2 3 4 5 6 7 8
Making direct comparisons between objects Language development Estimation Simple matching and comparison Ordering Simple relations and mapping Pictorial representation	Length Mass Volume*/capacity Time Area	
Comparing an object with a nonstandard unit (including parts of the body) Language development Estimation Simple matching and comparison Ordering Simple relations and mapping Pictorial representation	Length Mass Volume*/capacity Time Area Temperature	
Comparing an object with a standard unit (SI) Language development Estimation Simple matching and comparison Ordering Simple relations and mapping Pictorial representation	Length Mass Volume*/capacity Time Area Temperature	
Choosing measurement units for specific tasks Language development Estimation Simple matching and comparison Ordering Simple relations and mapping Pictorial representation	Length Mass Volume*/capacity Time Area	

*Solid volume (v^1) and displaced volume (v^2)

Piaget's research suggests that consideration must be given to the developmental level of each child as the instructional activities are planned for him/her. The activities need to be analyzed to insure that the child has the necessary prerequisite skills. To ask a child to perform a task for which he/she does not have the intellectual tools (is not developmentally ready for) is inhumane. This means we cannot rely upon grade level hierarchies of learning since Piaget's findings also indicate that there is nothing absolute about the age ranges for a particular stage. This means, for example, that some fifth graders may still be operating on a preoperational level in some areas.

A model instructional program is presented in Figure 2 (from California State Department of Education publication, **An Inservice Guide to Teaching Measurement**). If instruction is to be consistent with the nature of the learner, it **must** progress through these four stages of development. The first stage, Making Direct Comparisons Between Objects, involves simple matching and comparison activities such as identifying five objects in the room that are taller than you, or ordering objects from the largest to the smallest. To measure the length of one object by comparing it with another marks the beginning of measurement.

The second stage, Comparing An Object With A Nonstandard Unit, includes activities in which children measure linear dimensions of familiar objects in terms of pencils, drinking straws or pieces of string.

During the third stage, Comparing An Object With A Standard Unit, students will be involved in activities which require them to find the length of the hall in metres or determine how many millilitres of milk they drink at lunch, or collect five objects that are each one decimetre long or wide.

Choosing Measurement Units for Specific Tasks is the most advanced stage of measurement activities. Tasks that ask students to find a way to measure the thickness of one sheet of paper, or determine which metric unit(s) would be used to measure such items as a flea, a watermelon, a dog, a house, a nickle, a rope, or bucket of milk are typical for this stage.

Piaget's research has proven that making statements like, "By the end of third grade, all students should be able to.." is educationally unsound. Rather, the decision concerning when to teach particular concepts should be made in relation to the individual child's developmental level as determined by the various conservation tasks developed by Piaget. Figure 2 provides **general** guidelines about the appropriate grade level placement of various types of measurement activities. The lines indicate the levels at which a particular activity **MIGHT** be successfully done by **MOST** children. (Broken lines indicate that the measurement activity could be used with older children to reinforce measurement skills.)

Piaget states that if systematic measurement is to be "taught," it should not be presented before the latter part of what is usually third grade. Even then, for most children, it will have to be an experimental or trial-and-error readiness-type experience. As the activities in Chapter 4 are implemented, two factors must be considered:

1. Before attempting systematic measurement, the child **must** be able to conserve quantity. For example, until length of an object can be conserved, linear measurement is meaningless.
2. The child must understand the concept of partitioning a whole into congruent parts. For example, in order to measure a relatively long object, one could subdivide the object into parts the same length as the measuring instrument and then count the parts.

In summary, the instructional techniques employed to help children learn to measure should be a child-centered, "hands-on" activity approach. Each learner must make the observations, do the experiments, collect and interpret the data and draw the conclusions. For the child-centered activity approach to be most successful, the classroom should be organized in such a way that it can provide actual experiences with a variety of real objects and phenomena. Each child's discoveries are his/her own and are a direct result of his/her own actions and manipulations.

Chapter 4

MEASUREMENT LEARNING ACTIVITIES

It is desirable to provide appropriate measuring experiences for the learner as progress is made through the four stages of development in measuring described in Chapter 3. Examples of classroom activities which may be used at each of the four stages will be presented in this chapter. Before examining these activities, however, it might be fun to test your present knowledge of the metric system. The following self-test (programmed material) will identify your Triple M score.

Measure of Metric Mastery

Question: What two things are needed in measurement?

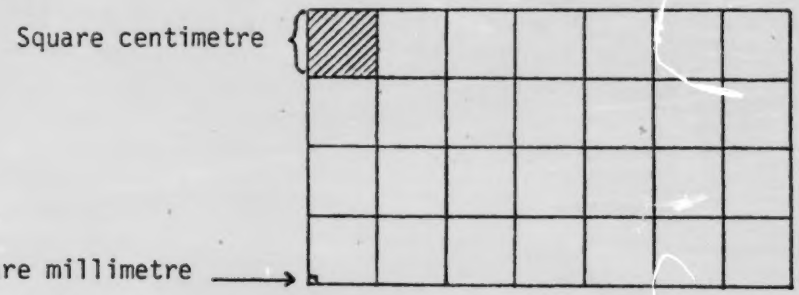
Answer: 1. something to measure
2. a measurement instrument

Question: What SI units are commonly used to measure length?

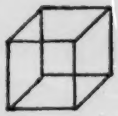
Answer: Millimetre, centimetre, metre, kilometre

Question: Area is frequently represented as the square of linear measure. What are some units commonly used to measure area?

Answer: Square millimetre, square centimetre, square metre, hectare



Question: A block of wood one centimetre high one centimetre wide and one centimetre deep would have a volume of _____



Answer: One cubic centimetre

Question: The metric unit usually used in measuring capacity is the litre. If gasoline costs 20 cents a litre, what would be the cost of 40 litres of gas?

Answer: 8 dollars

Question: Nine sticks of butter have a mass of about one kilogram. What is your approximate mass? You decide to miss lunch for a week. How will this affect your mass?

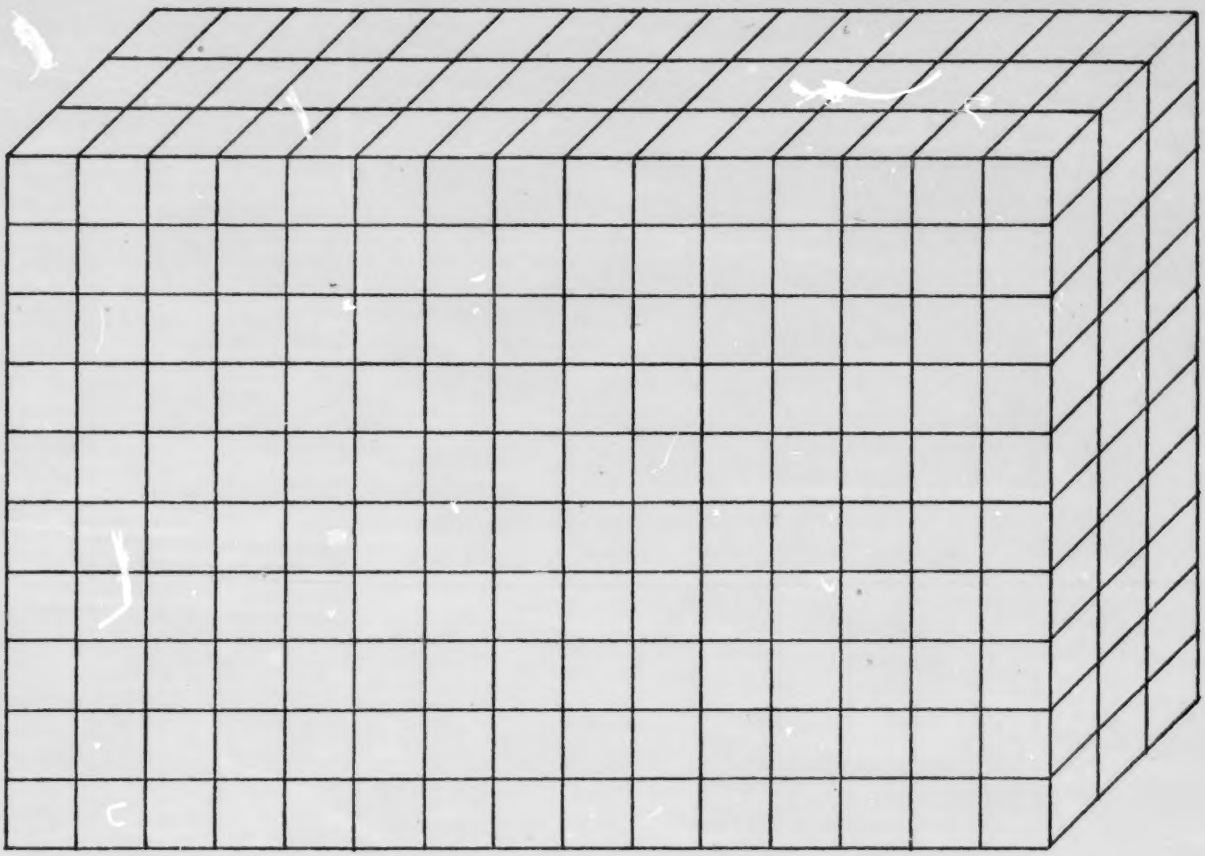
Question: How many stages of development in measuring were identified in Chapter 3?

Answer: Four--You may wish to review Chapter 3.

Question: Celsius degrees are generally used to denote temperature in metric system measurement. Normal temperatue for a human is about 37 degrees Celsius. If the outdoor temperature in Oklahoma City was 37 degrees Celsius, would you expect the month to be January or July?

Answer: July

Question: An ant habitat is being built by a fourth grade class. The glass container for the habitat is 3 centimetres deep, 15 centimetres wide and 10 centimetres high. If the container is completely filled with sand, how many cubic centimetres of sand will be needed for the ant habitat?



Answer: The volume of the ant habitat is 450 cubic centimetres.

Learner Objectives

Stated below are some objectives for teaching metric measurement. The activities in this chapter will help learners to:

1. Make simple comparisons between objects.
2. Arrange objects in order of magnitude.
3. Compare objects with non-standard units.
4. Compare objects with standard units (SI).
5. Estimate and measure to the nearest whole unit.
6. Use standard tools of metric measurement.
7. Use correct metric vocabulary.
8. Use the most appropriate metric unit for specific tasks.
9. Use SI symbols.
10. Describe the interrelationships between the various units used to measure length, capacity, mass.

Organization of Activities

The learning activities in the remainder of the chapter are organized according to the following strands: length, area, capacity, mass, and temperature. Within each strand, the activities are classified under the four developmental stages:

1. Making direct comparisons between objects.
2. Comparing an object with a non-standard unit.
3. Comparing an object with a standard unit (SI).
4. Choosing measurement units for specific tasks.

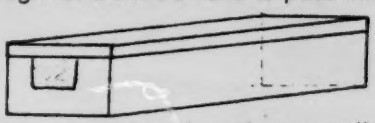
Length Measurement Activities

Stage one: Making direct comparisons between objects

THE SURPRISE BOX

The pupils can construct the surprise boxes. Let the children work in pairs. Each pair will need one shoe box (or a box of similar size. Have the pupils remove the lid from the box and cut a hole in one end of the box. The hole should be large enough for a child's hand to pass through.

The box may be decorated by the pupils.



For this activity, place objects in the box which have apparent length such as pencils, rules, sticks, etc. Objects such as balls should not be used. To begin, the first player removes two objects from the box. This player identifies which of these two objects is the longer. The second player withdraws two objects from the box and identifies the longer of the objects. The players compare the longer of their two objects. The player having the longest of the objects collects the four items. Play continues until the box is empty.

SECRET SOCK BOX

This game requires a large heavy sock, an oatmeal box, and several objects such as pencils, sticks, rulers, etc. Place the objects in the box and the box within the sock.

Two or more may play this game. The players take turns withdrawing objects from the box. The first object that is withdrawn is placed on the playing area. The second player withdraws an object and places it beside the first object. The next object withdrawn from the Secret Sock Box is placed with the first two objects but must be placed so that all three objects are arranged either in ascending or decending order. All objects withdrawn from the box must maintain the ordering of size which has been established. Any player who places an object in an incorrect position is eliminated.

Stage two: Comparing an object with a non-standard unit

MANY MERRY MEASUREMENTS

The following materials are required:

1. A collection of objects to be measured such as a book, box, desk and chair.
2. A sheet of paper listing the objects to be measured.
3. An appropriate but non-standard unit of measurement such as a pencil, the child's hand span, a piece of string, popsicle stick, or drinking straw. (The student may select the measuring device.)

The following are suggested:

1. Give the learner a sheet of paper on which the objects to be measured have been listed. Have the child draw a picture of the instrument of measurement on the sheet and measure the real objects selected for measurement. The child should record the results of the measurement on the paper which lists the objects.
2. Have the child measure the length of the classroom with a non-standard unit.
3. There may be objects out-of-doors that the student would like to measure.
4. Have several children record on the chalkboard their measurements of the same object.

Ask questions such as:

"What do you notice about the measurements?"
"Are all the measurements the same?"
"If not, why?"
"Can you think of a way the room could be measured so the answers would be more alike?"
(Elicit recognition of need for a standard unit.)

5. Give each learner a piece of string. All pieces of string should be the same length. Let the pupils give the length a name such as "Klig" or "Bloop." (The assumption is that the name given a unit of measure is an arbitrary decision.) Record their results on the chalkboard or on a chart. Have the class examine the answers and discuss the results. Ask:

"Are the measurements more alike?"

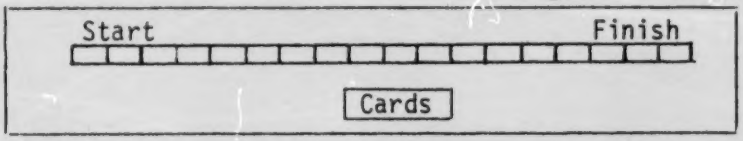
"If so, why do you think this happened?" (Elicit the fact that everyone used the same unit of measurement.)

Discuss the name given their unit. Ask:

"Do you think children in other classes would know what you meant if you said the room was _____ Kligs long? If not, why?" (Bring out the need for a name that people everywhere would understand.)

THE UNIT PATH -- Part 1

On poster board, sketch as shown below. All the small markings are one centimetre in length.



Make a set of cards to go in the area marked for the cards on the playing board above. On the cards, give directions such as:

forward 2 units	back 6 units

There should be about 20 cards in the set. Make a ruler 10 centimetres long for each player (see Appendix F). Tag board or construction paper would be appropriate for the ruler construction. Do not indicate the measuring unit being used. Do not number the units on the rulers.

Two to four players may play this game. Place the set of cards on the board face down. The players take turns drawing the cards. As a card is drawn, the player moves the playing piece along the board according to the directions on the card. The player must measure the distance to move by using the ruler. No player is required to move back beyond the START. The first player to cross the finish line is the winner.

Stage three: Comparing an object with a standard unit (SI)

THE UNIT PATH -- Part 2

The playing board is the same as the one shown above in THE UNIT PATH -- Part 1. Make two sets of twenty cards each. On the first set of cards, give directions such as:

forward 2 centimetres	back 6 centimetres

On the second set of cards, give directions such as:

forward 2 cm	back 6 cm

Each player will need a 10 cm ruler as in THE UNIT PATH -- Part 1. Play as in THE UNIT PATH -- Part 1 using the first set of cards. As the children progress, replace the first set of cards with the second.

ESTIMATION

Have the pupils find things in the room to measure to the nearest centimetre. (Suggest such things as a pencil, chalk box, teacher's key, a book, a small box, light switch, etc.) Make a chart like the one below. Be sure they estimate each length before they measure. Let children add objects of their choice to the list.

Estimate and then measure

Object	Estimation (a guess)	Actual Measurement
1. pencil	cm	cm
2. chalk box	cm	cm
3. book	cm	cm
4. light switch	cm	cm
5.	cm	cm

SCAVENGER UNIT

Make cards listing lengths of specific objects in the room. Divide the class into groups. Give each group a card and have them find the objects whose lengths are listed on their card.

MEASURE STRIPS FROM COLORED TAPE

Stick strips of colored tape around the room on tables, walls, doors, etc. Each pupil will need a centimetre ruler and a sheet with questions similar to those below. Have the children move around the room measuring the tape and answering the questions on the sheet. It is suggested that all strips of the same color of tape be the same length.

QUESTIONS: How long is the green strip? What strip is twice as long as the blue strip? How much longer is the red strip than the yellow strip? If you placed the orange strip at the end of the brown strip, how long would the new strip be?

LET'S MAKE A METRE

Use the pattern found in Appendix F to make a metre marked in centimetres. Have each pupil cut out the lengths and put them together. Pupils may want to number them to see how many centimetres there are in one metre.

Have the pupils fill in the following chart using their metre measurer.

Object	Estimated length in centimetres	Actual length in centimetres	Length in metres
desk (width)			
height			
chalkboard (length)			
the paper			

Discuss which unit was more appropriate for measuring each item. Have each pupil compute the difference between the estimate and the actual measurement.

THE RACE

Prepare a place for running 100 metres. The playground may be utilized. Let pupils measure off this distance.

Ask: "How long do you think it will take you to run 100 metres?" "How many seconds?"

Two children could work as a team and time each other.

Let the pupils measure off a distance of 10 metres. This may be used for the "DEKAMETRE SPRINT."

The 100 metre race, dekametre sprint and other activities such as the broad jump and relay race may be combined to create a METRIC FIELD DAY.

WHAT'S LONGER THAN A METRE?

Materials: 10 balls of heavy chord, 10 metre sticks

Directions: Divide the class into 10 teams.
Note: Allow the children to work out as many of the details in the activities without assistance as possible.

Suggestions:

1. Present the team with the following puzzle: Ten dekametres is one hectometre. (10 dam = 1 hm)

Use the chord and metre sticks to find the length of 10 dekametres on the school ground.

The problem may be solved by group effort. If each group marks off ten metres on their ball of chord, each of the ten groups would have a length of one dekametre. Should the ten groups stand end to end with the chord stretched out, the length would be 10 dekametres.

Ask the children to tell you another name for the length of 10 dekametres.

2. Find long lengths around the school ground that the children could measure, such as sidewalks. (A walk might be 2 hm 1 dam 6 m. This answer could also be represented in metres.)

3. After the class has had adequate experience with hectometres, you could introduce kilometre. (10 hectometres is 1 kilometre)

The length around some school grounds is more than one kilometre. It may be useful to remember that 5 hectometres is one-half or 0.5 kilometre.

NEED A SMALLER UNIT?

Have trays of small thin objects for groups of students to use, such as: penny, dime, paper clip, poker chip, rubber band, etc.

Ask: "Can you find the thickness of each of your objects using a centimetre ruler?" (Elicit need for smaller unit.)

Explain and show how a centimetre can be divided into 10 equal parts.
Each part is called a millimetre. How many millimetres would it take to make a metre?

MEASURING WITH THE MILLIMETRE

Have children estimate and find the thickness of a set of objects to the nearest millimetre. Record and compare the results.

Thickness of Objects

Object	Estimate in millimetres	Measurement to nearest millimetre
Rubber band		
Paper clip		
Poker chip		
Tin can		

Stage four: Choose appropriate unit for specific task

WHAT ARE YOUR MEASUREMENTS?

Directions: Check the following and record your measurements:

Wrist _____ Foot _____

Neck _____ Waist _____

Elbow _____ Head _____

Finger tip of one hand to finger tip of the other with arms extended _____ Knee _____

Height _____

Note: It may be necessary to use string and then measure the string if you do not have enough tape measures. This is a good activity for small groups.

CHOOSE THE RIGHT UNIT

Fill in the chart below: Choose the appropriate unit–mm, cm, dm, m, km

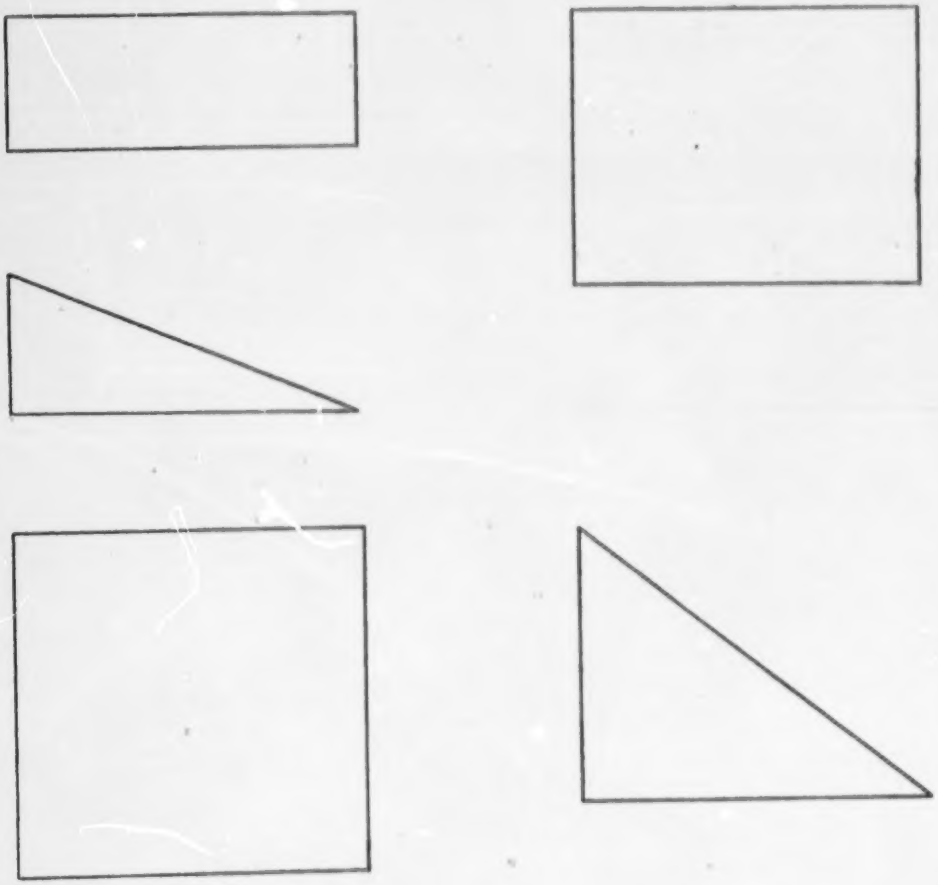
Other objects may be listed in the object column.

Object	Estimate	Actual	Instrument used
Room length			
Width of door			
Your height			
Length of a new crayon			
Length of your arm			
Width of a penny			
A new pencil			
Length of playground			
Your paper			

Stage One: Making direct comparisons between objects

COMPARING REGIONS

Directions: Cut out regions of various shapes such as the ones below. Have the child compare the areas of the regions and arrange the regions in order from smallest to largest.



CHINESE TANGRAMS

Use the pattern in Appendix F to construct a tangram puzzle for each pupil. Allow time for exploration and recognition of the different shapes.

Suppose that the small triangle is the unit for measuring area.

What is the area of the small square? (2)

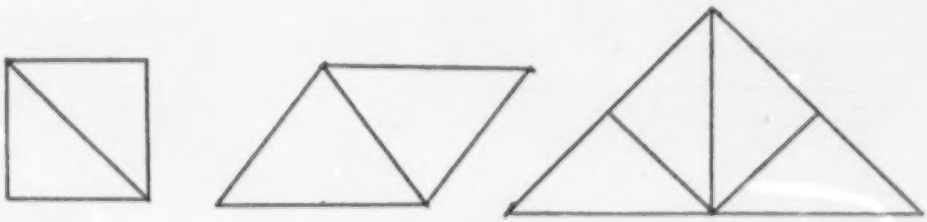
What is the area of the parallelogram? (2)

What is the area of the middle size triangle? (2)

What is the area of one of the large triangles? (4)

Have pupils "prove" their answers by tracing around the pieces:

For example:



Use all seven pieces to construct a square. What is its area?
(By addition it is 1 + 1 + 2 + 2 + 2 + 4 + 4 = 16.)

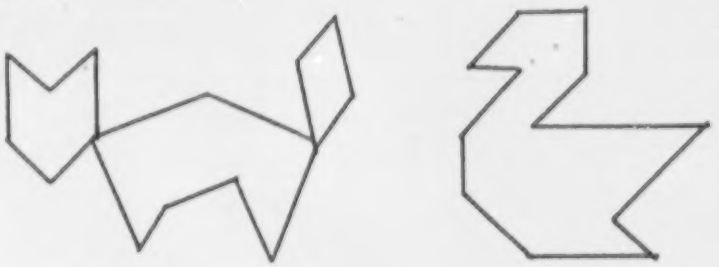
Can you make a triangle using all seven pieces? What is its area? (16)

Using the small square as the unit of area, what is the area of each of the other pieces?

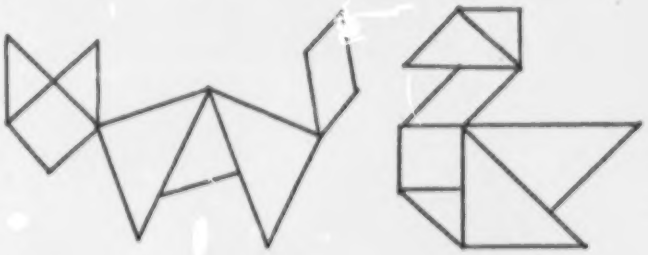
CHINESE TANGRAM PUZZLE

In solving Chinese Tangram Puzzles, the player is required to use the seven shapes to make a silhouette. There are two rules which must be followed: All seven pieces must be used to make the silhouette. No two pieces may overlap.

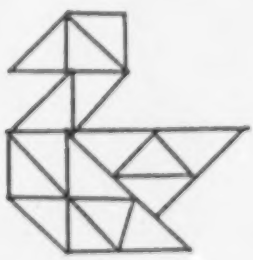
Examples of silouettes:



Solutions to the two puzzles:



Give the pupil a set of Tangram Puzzle pieces and a silhouette puzzle to solve. Scale the silhouette puzzle so that the silhouette puzzle picture is congruent to the silhouette made from the Tangram Puzzle pieces. If this is done, the pupil may place the 7 pieces on top of the silhouette while solving the puzzle. After the puzzle has been solved, have the pupil remove all 7 pieces from the silhouette. Taking the small right triangle, have the pupil count the number of small right triangles within the silhouette. The area of the silhouette should be 16 triangular regions.



ENVIRONMENT MEASURE

Make up your own unit for measuring surfaces (area). Draw it in the square below and cut it out. Measure some surfaces with your unit. Your book and desk would be things you could measure.

Draw your unit here.
Then cut it out.

Item	Number of Units
1.	
2.	
3.	
4.	
5.	
6.	
7.	

Did you have any problems measuring the total surface with your unit? How could you make it easier to measure surfaces?

Stage three: Comparing an object with a standard unit (SI)

AREA STUDY ON THE GRID

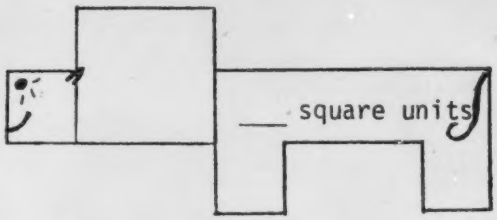
Materials:

transparent cenimetre grid (Master in Appendix F may be used to make the transparency.)
tagboard
clear contact paper
watercolor pens or black crayons

Construction Directions:

Cut squares, rectangles, and shapes made by combining squares and rectangles from the tagboard. Be sure that all figures have measures that are a whole number of units.

On each figure write
_____ square units.



Cover the figures in clear contact paper. Make some different shaped figures having the same area. (Example: a square 4 units by 4 units and a rectangle 2 units by 8 units.)

Have the pupil place the grid over one of the geometric shapes. Count the number of square units within the figure. Record this value (the area of the figure) in the blank on the figure using either a crayon or a watercolor pen. Wipe the figure clean.

Have the pupils arrange the shapes in order from smallest area to largest area. Use the grid to let the pupils check themselves. The figures may be wiped clean.

Instead of cutting out the geometric shapes and covering them with clear contact paper, the shapes may be drawn on a sheet of paper, reproduced and given to the pupils.

GRID MEASURE

Materials:

1. a transparent centimetre grid
2. tagboard
3. clear contact paper
4. watercolor pens (soft crayons may be substituted)

Construction Directions:

On a sheet of paper draw patterns such as the following:

square region 4 centimetres by 4 centimetres
rectangular region 8 centimetres by 2 centimetres
square region 3 centimetres by 3 centimetres
rectangular region 2 centimetres by 3 centimetres
rectangular region 4 centimetres by 5.5 centimetres
rectangular region 6 centimetres by 3.5 centimetres

Reproduce this sheet so that each pupil may receive a copy. Have the pupils cut out the regions. The learner will need a copy of the sheet of regions, a centimetre ruler and a clear centimetre grid. (Note: If transparent grids are not available, the suggested learning strategies may be adjusted for use with a centimetre grid that is in Appendix F.)

Suggestions:

1. Using a centimetre ruler, let the pupil measure the grid. Identify the length and width of the grid to the nearest centimetre. Observe the distance between the horizontal lines (vertical lines) on the grid. It would be appropriate at this time to name each of the small regions on the grid as a square centimetre.
2. Tell the pupil to place one of the regions on the desk. Place the grid over the figure. Find the number of centimetre squares within the figure and record the findings.
3. Have the pupil give the dimensions of the figure as well as the area. All of these measures may be found by counting on the grid.
4. Repeat activity two with one exception--place the figure on top of the grid.

Note: It is recommended that the pupil's first experience with these activities be with the regions that do not involve fractional units.

5. On a grid such as the one found in Appendix F, have the pupil draw three different rectangles. Each rectangle is to have an area of 16 square centimetres (16 cm^2).

Have each pupil find the perimeter of the different regions. Ask:

"If two rectangles have the same area, do they have the same perimeter?"
"Which of your rectangles has the smallest perimeter?"
"If two rectangles have the same perimeter, do they have the same area?"

IDENTIFYING THE SQUARE METRE

Materials:

25 sheets of notebook or typing paper or several sheets of newspaper
ruler marked in cm or dm
scissors
pencil

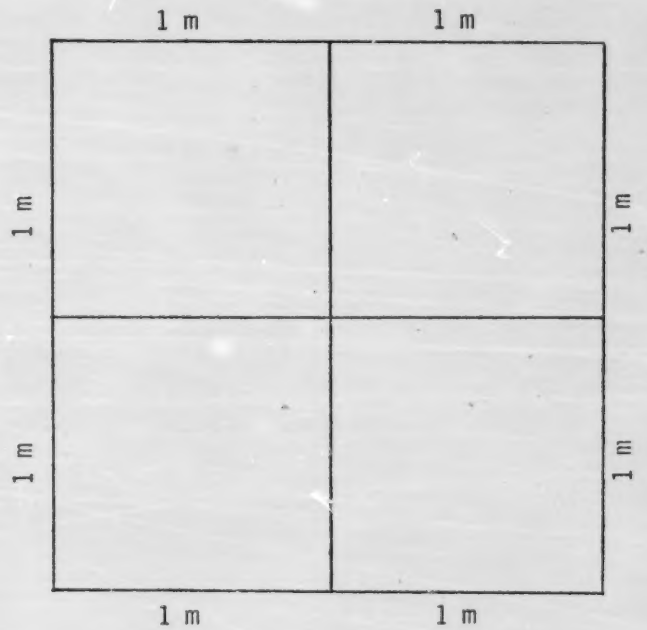
Directions:

Have the pupils cut 100 squares, one dm (10 cm) on each side, and arrange them on the floor in a square (without overlapping) 10 dm (100 cm) on each side. This is 1 square metre.

Allow them to arrange the squares in various other shapes to recognize that 1 square metre is not necessarily square.

Abbreviation for square metre is m^2.

Have the pupils identify the number of square metres in the floor of the classroom. It is suggested that pupils first estimate the area of the floor, then measure.



Note: The above is a scale drawing of a 2 metre square. However, the area is 4 square metres.

HOW MANY HECTARES?

An area of 10 000 square metres (10 000 m^2) is called a hectare. Have the pupils find the number of hectares in each of the following pieces of land?

1. 100 metres long and 100 metres wide
2. 200 metres long and 100 metres wide
3. 200 metres long and 300 metres wide
4. 50 metres long and 100 metres wide

Stage four: Choosing measurement units for specific tasks

IDENTIFY THE UNIT NEEDED

Have the pupils make a one metre square on brown wrapping paper and a one centimetre square on notebook paper. Cut out both the metre square and the centimetre square. Give each student a list of objects. Have them identify which of the objects it would be practical to measure using the centimetre square and which of the objects it would be practical to measure using the metre square. Have the pupils estimate and then measure the area of the objects.

Volume/Capacity Measurement Activities

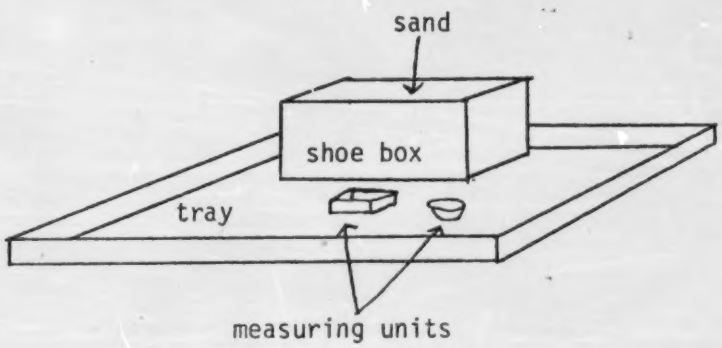
Stage one: Making direct comparisons between objects

Materials:

1. A large tray with a rim. (A dress box will work.)
2. A container for the material to be measured. (A shoe box may be used.)
3. Material to be measured (sand or beans).
4. Containers such as cups and cut-off milk cartons. (It would be excellent if two very different shapes with the same capacity were used.)

Directions:

Arrange the materials as illustrated.



Suggestions:

1. Ask the pupils which container holds the most sand. Have the pupil explain the answer. Explain that capacity refers to the amount of material a container holds.
2. Have the pupil fill one of the containers from another container unit. Ask which has the greater capacity. Have the pupil explain the answer.

Stage two: Comparing an object with a non-standard unit

WHY DO WE NEED A STANDARD UNIT?

Divide the class into four or more groups. Each group will represent a different city such as City A, City B, City C and City D.

Give each city a set of identical containers. (The city may have a mayor who is in charge. The other members are on the commission.) Their job is to find the capacity of each container. The only thing they have to measure the capacity of their containers with is a cup. (Each city has a different sized cup.)

Have materials available for measuring capacity, such as sand, water, beans, etc. (particles that are easy to handle).

Pupils record the results on the board or a chart. Let them discuss the results. (Elicit the need for a standard unit.)

Ask:

"What problems would the cities have if they tried to trade with each other? How do you think the cities could solve their problems?" (Elicit using the same sized cup or unit.)

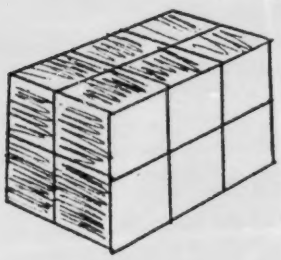
Keep the set of containers for use later in a second activity. In this activity, give each "city" a cup (jar, etc.) All cups are to be the same size. Using the cups as a measuring device, repeat the experiment. Discuss the results.

HOW MANY BLOCKS?

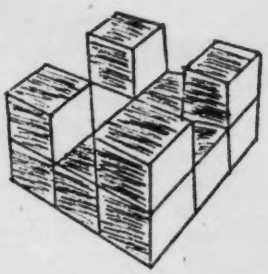
A. Estimate the number of blocks in each picture.

B. With cubes construct the building and count the blocks.

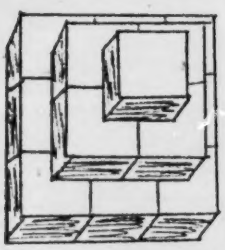
C. How close was your estimate?



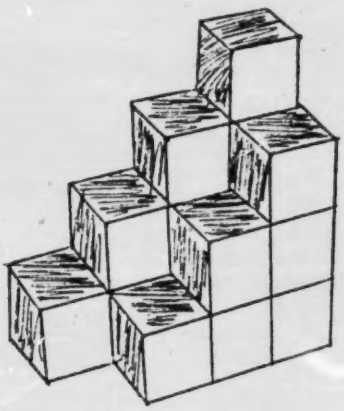
A. _____
B. _____
C. _____



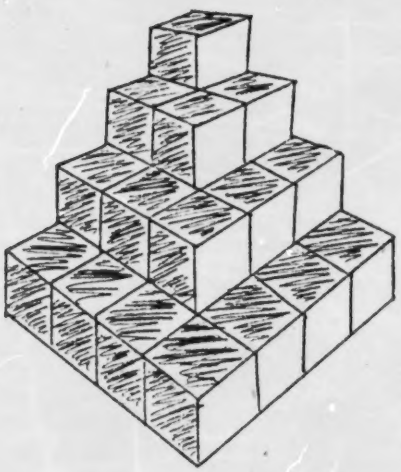
A. _____
B. _____
C. _____



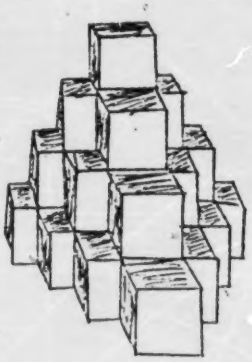
A. _____
B. _____
C. _____



A. _____
B. _____
C. _____



A. _____
B. _____
C. _____



A. _____
B. _____
C. _____

Stage three: Comparing an object with a standard unit (SI)

THE LITRE BOX

Materials:

- Tagboard
- Heavy tape
- Shoe box
- Sand
- Tray (or dress box)
- Miscellaneous containers

Suggestions:

1. Construct a box with a capacity of 1 litre using the pattern provided in Appendix F.
2. Place the sand in the shoe box. Place the shoe box, milk carton, litre box and miscellaneous containers on the tray.
3. Label the miscellaneous containers whose capacity is to be measured. Have pupils arrange the containers in order from smallest to largest by directly comparing them. Fill the litre box with sand. Pour the sand from the litre box into the container to be measured. Record, on the drawing, the number of litres contained in the miscellaneous containers. Should the measure not be an even number of litres, estimate the fractional part of the litre needed to fill the container and record this on the paper.
4. Repeat the above activity with the following change. Fill the miscellaneous container first. Determine the number of litres in the container by pouring the sand from that container into the litre box.

WE NEED A SMALLER UNIT

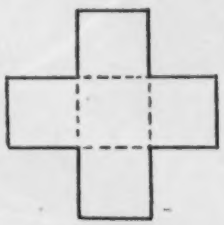
Give the pupils a set of 3 containers, each of which is smaller than a litre (such as aspirin bottle, medicine bottle, jar lid, etc.) Ask: "Do you think a litre would be a good unit to find the capacity of these?" (Elicit "No, they are too small.") "What do you think we could do?" (Elicit "Divide the litre into smaller parts.")

Give the pupils a medicine dropper or a plastic spoon and see if they can find the capacity of the containers. Record and compare answers. Discuss the differences and need for a standard unit.

Have the pupils construct a cubic centimetre box from the pattern at the right. Fill it with water. Explain that this is a small standard unit that can be used. The amount of water this holds is one millilitre. Help pupils understand:

1000 millilitres = 1 litre
milli **means** one thousandth
1 litre = 1000 ml
3 litres = _____ ml

(Fold on dotted lines)



Note: A millilitre box made from an index card, using the pattern above, will hold water. If graduated cylinders are not available, pupils could calibrate their own cylinders using olive jars, pill vials, etc. with the help of the millilitre box.

ESTIMATE AND MEASURE USING THE MILLILITRE

Using the medicine dropper, see how many drops of water it takes to fill the millilitre box. ___

How many millilitres of water can you put into the containers used in the previous activity?
_____ ml

How many millilitres can you put into the litre box previously made?_____

USING THE MILLILITRE UNIT

Have an assortment of containers on a tray such as small jars, cans, etc. Have the children estimate and then measure the capacity of each of these in millilitres. The pupils should record their answers on a chart like the one below.

Container	Estimated Capacity	Measured Capacity	Difference

THE KILOLITRE

Have the children construct a model of one cubic metre as shown in Appendix F. Have children answer the following:

1. How many children can fit inside the box?
2. How many boxes of this size would it take to fill the classroom?
3. How many litre boxes would it take to fill the cubic metre box?
4. What is another name for the capacity of the cubic metre box? (kilolitre)
5. Give examples in which the kilolitre would be an appropriate measuring unit. (Amount of water in swimming pool, amount of gasoline in a large storage tank.)

Stage four: Choosing measurement units for specific tasks

ESTIMATING CAPACITY

1. Give a list of containers of various sizes (jars, cans, buckets, etc.) Have the children tell which unit--millilitre, litre, or kilolitre--would be most appropriate in measuring particular containers.

2. List some of the containers on a chart like the one below. Have the children complete the chart by giving their estimates of the capacity and then the actual measuements of the capacity of the containers.

Object	Estimate	Actual Measurement	Difference

Mass Measurement Activities

Stage one: Making direct comparisons between objects

COMPARING MASS

Materials: Objects common to a child's experience such as an orange, a pencil, a ball, etc.
Balance scale (Various ways of constructing a simple balance scale are given in Appendix F.)

1. Have a child hold an object in each hand. Ask the child to identify the heavier (lighter) object.
2. Have the child arrange several objects from lightest to heaviest by direct comparison as in step 1.
3. Have the child check his/her responses by using a simple balance scale to compare objects.

Stage two: Comparing an object with a non-standard unit

Materials: Several objects of the same mass to use as measuring units (bolts, nuts, washers, marbles, beads, paper clips, etc.)
Various objects to be measured
Balance scale

Directions:
Divide the class into small groups. Give each group several objects of the same kind (same mass) to be used as units of measurement. Each group should have a balance scale and several objects to measure. Have each group measure the objects and record their answers in a chart like the one below. Make sure that several groups measure the same objects but with different units. Discuss the differences in the answers reported by the groups.

Group A Unit Used washers

Object	Estimate	Measurement

Stage three: Comparing an object with a standard unit (SI)

MAKING AND USING A KILOGRAM MASS

Materials: Tagboard, tape, balance scale, kilogram mass piece, several objects to be measured.

Directions:

Construct a litre box using the directions given in Appendix F. Place a plastic baggie in the box and then fill the box with cold water by pouring it into the baggie. Using the balance scale, compare the litre of water with the kilogram mass piece.

Find several objects that you estimate to have a mass of about one kilogram. Verify by using the balance scale and the litre of water.

Find other objects that have a mass of more than one kilogram. Estimate the mass and then verify by using the balance scale and mass pieces. Record on a chart like the one below.

Object	Estimated Mass	Measurement

MASS CHART

Materials: Bathroom scale marked in kilograms

Directions:

Make a chart like the one below and record the mass of each child in the class.

Name	Mass in kg

Use the bathroom scale to measure the mass of a variety of things such as buckets of sand, stacks of books, etc. Estimate and then measure. Record in a table like the one below.

Name of Object	Estimate	Measurement

Use a kitchen mass scale or an equal arm balance and mass pieces of 1 g, 5 g, 10 g, 20 g, 50 g to measure the mass of a variety of items such as coins, keys, and quantities of cooking ingredients. Estimate and then measure. Record in a chart such as the one below.

Object	Estimate	Measurement

Stage four: Choose appropriate measuring unit for a specific task

Provide a variety of objects, both heavy and light. Have the child select the appropriate unit and estimate the mass of each object. Then have the child check his/her estimate by actual measurement. Try to include some objects that are large in volume but have small mass, and also some that have a small volume but are relatively heavy.

Temperature Measurement Activities

Stage one: Making direct comparisons between objects

Give pupils objects having different temperatures. Have them identify the warmest and the coolest.

Stage two: Comparing an object with a non-standard unit

Prepare three containers of water before class. Container A should be ice water, Container B should be room temperature, and Container C should be warm water. Place the containers on a table. Have one student put one hand in Container A and the other hand in Container C and leave them there for two minutes. Now, have the student move the hand in Container A to Container B. Ask what she/he thinks is the temperature of the water in Container B. The reply will probably be "It is hot water." Next, have the student move the hand in Container C to Container B. Ask what she/he thinks now. The student will probably say that the water feels cold. Elicit the response from the class that we need a more reliable way of measuring temperature.

Stage three: Comparing an object with a standard unit (SI)

Make a chart like the one below. Record temperature for a week or more. Use a Celsius thermometer.

Days	Our Forecast	Actual Temperature
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		

Provide opportunities for the children to use the Celsius thermometer to measure a variety of temperatures such as temperature of ice water, very hot water, air just above an asphalt parking lot, air under the shade of a tree, air inside air conditioned room.

Chapter 5

ADMINISTRATIVE IMPLICATIONS AND RECOMMENDATIONS

The problem of introducing new topics into a school curriculum can be very complex. No one particular method necessarily works for all schools. Some suggestions to school administrators and teachers are presented in the following material. Each school system should select and apply ideas that are appropriate for their given situation.

GENERAL RECOMMENDATIONS

1. The school must recognize that the metric system has been nationally adopted and voluntary conversion should proceed with responsibility. (Metric Conversion Act of 1975-Public Law 94-168)
2. The school is responsible for leadership in any curricular change and the classroom teacher has the final responsibility for implementation of new curricular materials.
3. Faculty meetings can be utilized by keeping the total faculty aware of the progress at each grade level as metric education is implemented in the curriculum.
4. Administrators and school boards should recognize that a curricular change can be a traumatic experience for some teachers. These teachers should be encouraged by the administration showing interest in the metric education of the children and by positive reinforcement of the teachers' efforts while they are in the midst of the change to the metric system.
5. Since measurement applications are abundant in everyday experiences of citizens and in various occupations and careers, administrators need to use an interdisciplinary approach in metric instruction. Mathematics teachers should have the principle responsibility for teaching measurement concepts, but application of these concepts can be provided by teachers of other subjects such as by science, geography, foreign language, industrial arts, and home economics.

TEACHER PREPARATION

Adequate provision should be made for long range improvement of the competence in metric education of both the teachers and the administrators. Each teacher needs approximately ten to fifteen hours of workshop on inservice instruction in order to be adequately prepared to teach measurement using SI metrics. Teachers of all subjects need to learn to use the system. Elementary and middle school mathematics teachers, especially, need to know how children acquire measurement concepts, and be familiar with various methods of teaching measurement concepts and skills.

Cooperative planning between local school districts, regional service centers, colleges and universities, and the State Department of Education can accomplish the task of preparing all Oklahoma elementary teachers to use and teach the metric system of measurement.

INSTRUCTIONAL MATERIALS

Adequate instruction in measurement requires the use of a variety of materials. Measurement skills are acquired through actual experiences using measuring instruments and comparing the dimensions of a variety of objects. These new teaching aids will be needed in each classroom. Metre sticks, litre containers, and mass sets should be available for use (see Appendix C for a list of suggested materials). Library materials and audio-visual materials such as films, filmstrips, charts, etc., should be available.

Textbooks that do not have metric measurement topics can be used if teachers rewrite problems that apply measurement concepts. Supplementary activity books may be used to provide metric experiences. Teachers and administrators should take the responsibility of encouraging the state textbook commission to adopt textbooks that utilize the metric system throughout the individual books and the series.

PUBLIC AWARENESS

One of the major problems occurring as a result of the change to metric measurement is the problem of educating the general public. School administrators need to provide for metric awareness programs for the public. This should include all non-teaching personnel in the school system as well as parents. Parents need to be informed as curricular changes take place. Special parent sessions on metric education may be necessary. It is essential that the persons who conduct these meetings have the ability to communicate well and "sell" the idea of changing to metric measurement. Public awareness sessions should include experiences such as comparing grocery prices of items marked in metric units, using metric sewing patterns, automobile specifications, medicines, films, etc.

APPENDIX A

Classroom teachers need sources for reference in teaching the metric system of measurement. However, in a field that is changing as rapidly as metric education, it is impossible to compile a comprehensive list of all available publications and materials. The following is a representative list of publications and sources.

ERIC Information Analysis Center for Science, Mathematics and Environmental Education has published **Materials for Metric Instruction.** It is a good source of information for the teacher who is looking for supplementary metric materials other than books or workbooks. The publication lists available kits, task cards, films, filmstrips, slides, and other miscellaneous metric materials. Information on the name and address of the commercial distributor, cost of the kit, level of intended use, and comments is included. The report can be ordered from:

ERIC Information Analysis Center for Science,
Mathematics and Environmental
400 Lincoln Tower
Columbus, Ohio 43210

The California State Department of Education has developed a Source Book of Metric Materials and Equipment for Educators for the Five-State Consortium on Metric Education. It contains an extensive list of films, kits, games, instructional aids, and measuring devices for use in the classroom. This booklet can be ordered from:

Publications Bureau
California State Department of Education
Sacramento, California 95814

APPENDIX B

Sources of Information

Organizations

American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, DC 20036

American National Standards Institute, 1430 Broadway, New York 10018

American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103

Metric Studies Center, American Institutes for Research, Box 1113, Palo Alto, California 94302

National Bureau of Standards, Metric Information Office, Washington, DC 20234

National Council of Teachers of Mathematics, 1906 Association Drive, Reston, Virginia 22091

Public Affairs Office, George C. Marshall Space Flight Center, Alabama 35812

U.S. Metric Association, Sugarloaf Star Route, Boulder, Colorado 80302

Pamphlets and Handbooks

A Metric Handbook for Teachers, Jon Higgins, editor. National Council of Teachers of Mathematics, 1906 Association Drive, Reston, Virginia 22091 (April, 1973)

In-Service Guide to Teaching Measurement, (K-8) California State Department of Education, Sacramento, California 95814 (1973)

In-Service Guide to Teaching Metric Measurement. Mathematics Service, Division of Secondary Education, State Department of Education, Richmond, Viginia 23216 (August, 1975)

Interstate Consortium on Metric Education-Final Report. California State Department of Education, Sacramento, California 95814 (1975)

Let's Measure Metric. Division of Educational Redesign and Renewal, Ohio Department of Education, Columbus, Ohio 43215 (1975)

Metrication Aids for Teachers. Division of Instructional Services, Arkansas Department of Education, Little Rock, Arkansas 72201 (1975)

Metric Measurement: A Handbook for Educators. State of Washington, Office of Superintendent of Public Instruction, Old Capitol Bldg., Olympia, Washington 98504

Metric Style Guide. Council of Ministers of Education, Canada, 252 Bloom Street West, Toronto, Ontario, Canada M551V5 (1975)

National Bureau of Standards Metric Guidelines, Metric Practice Guide and Style Manual. AMJ Publishing Company, Polymetric Servies, Inc., Tarzana, California 91356 (1975)

Successful Experiences in Teaching Metrics. NBS Special Publication 441, Superintendent of Documents, U.S. Government Printing Offie, Washington, DC 20402 (1976)

The International System of Units (SI). NBS Special Publication 330, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 (1974)

Trueblood, Cecil A., **Metric Measurement Activities and Bulletin Boards**. Instructor Publications, Inc., Danville, New York (1973)

Selected Articles from Professional Journals

Choate, S.A., "Metric Bibliography," **The Mathematics Teacher,** LXVII (November, 1974), pp. 586-7

Dubisch, Roy, "Some Comments on Teaching the Metric System," **The Arithmetic Teacher,** XXIII (February, 1976), pp. 106-7

Firi, D. H., "Move to Metric: Some Considerations; Systems Internationale D'Unites," **The Mathematics Teacher,** LXVII (November, 1974), pp. 581-4

Joly, R. W., "Changing to the Metric System: An Idea Whose Time Has Come," **NASSP Bulletin,** LVI (November, 1973), pp. 47-59

King, I. and N. Whitman, "Going Metric in Hawaii," **The Arithmetic Teacher,** XX (April, 1973), pp. 258-60

Milek, John T. and Valeria Antoine, "Bibliography of the Metric System," Clouder, Colorado: Metric Association, n.d.

National Bureau of Standards, "A Metric America" and "A Metric Conversion Case Study," **Technical News Bulletin,** Government Printing Office, Washington, DC

Peavier, C.S., "Metricating: Painlessly, Cheaply, Cooperatively," **The Arithmetic Teacher,** XXI (October, 1974), pp.533-6

Shumway, R. J. and L. Sachs, "Don't Just Think Metric, Live Metric," **The Arithmetic Teacher,** XXII (February, 1975), pp. 103-110

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APPENDIX C

Suggested Measurement Materials and Equipment

The following materials are recommended for each classroom.

1. A 20 cm or 30 cm ruler for each student, graduated only in metric units (e.g., marked in cm on one side and mm on the other side)
2. Several plastic tape measures (150 cm)
3. Several metre sticks
4. Models of square decimetres and square metres
5. Square centimetre grids (transparencies) for estimating areas
6. Cubic centimetre blocks and cubic decimetre containers
7. Beakers or cylinders graduated in millilitre and litre units
8. Double pan balance with gram and kilogram mass pieces
9. A Celsius thermometer
10. Personal scales for mass in kilograms

APPENDIX D

CHECKLIST OF CRITERIA FOR EVALUATING INSTRUCTIONAL MATERIALS IN METRICS

As the United States moves toward the predominant use of SI metrics, more and more metric instructional materials are becoming available to educators. It is important that educators examine these materials carefully to insure that the materials they use adhere to recommended practice. The following checklist can be used to help individuals decide on the relative merits of the material examined.

A. CONVERSIONS

Numerical conversions are not recommended in elementary measurement programs. However, in some vocational education programs, numerical conversions between units may be needed.

1. Numerical conversions **between** measurement systems should be avoided. Instead, comparisons to familiar objects should be used.
   Example: A metre is a little longer than a yard.
   NOT
   There are 39.37 inches in a metre.
   A kilogram is a little more than two pounds.
   NOT
   There are 2.2 pounds in a kilogram.
2. Numerical conversions within the metric system may be made after students have been introduced to the decimal relation that exists between the prefixes. However, conversions should be limited to the commonly used units:

Length	Mass	Capacity
km	kg	kl
m	g	l
dm		
cm		
mm	mg	ml

B. SYMBOLS

Correct usage of SI symbols should be stressed:

1. Symbols are not punctuated with periods, except at the end of a sentence.
   Example: kg NOT kg.
2. Symbols for units do not have plural forms.
   Example: 10 kg NOT 10 kgs
3. A space is left between the number and the unit symbol; the only exception to this rule is for the location of the symbols used with plane angles and degree Celsius.

   Example: 25 mm, 27 °C, and 90°
   NOT
   25mm, 27 °C. and 90 °
4. A script "*l*" should be used as the symbol for litre to avoid confusing it with the numeral one (1).
5. Exponential index numbers are used with symbols to signify "square" or "cubic" units.

   Example: cm^2 (square centimetre)
   cm^3 (cubic centimetre)
   NOT
   c.c. (cubic centimetre)

6. The symbol for "per" is a slash "/"
   Example: 90 km/h or 90 kilometres per hour
   NOT
   90 k.p.h. or 90 km per h

C. **NUMBERS**

In recording measurements, decimal notation should be used.

1. When writing numbers less than one, a zero is placed in front of the decimal point.
   Example: 0.25 m NOT .25 m
2. A **space,** rather than a comma, should be used for indicating how numbers are grouped. In numbers of four digits, no space is recommended.
   Example: 5000 km NOT 5,000 km
   36 000 km NOT 36,000 km

D. **MASS AND WEIGHT**

In instructional materials, the term weight should not be employed to refer to the concept of mass. This recommendation is made because in scientific applications the word weight has been defined to refer to the concept of force; whereas, in common practice, weight has been used to refer to both the concept of mass and force.

E. **DUAL PRESENTATIONS OF U.S. CUSTOMARY AND METRIC UNITS**

Dual presentations should be avoided. If the U.S. customary system is taught, it should be presented as part of the development of measurement before standard units of measure (SI) are considered.

F. **MEASUREMENT INTRODUCTION**

1. Measurement is best learned through an activity approach.
2. Instructional materials produced for students in elementary grades should reflect a genuine concern for how and when children learn to measure. The materials should be organized so that the student is aware of the comparisons he is making. An example of an appropriate sequence is as follows:
   a. Comparison between objects
   b. Comparing objects with non-standard units
   c. Comparing objects to be measured with SI units
   d. Choosing measurement units of appropriate size for specific tasks

APPENDIX E

SI Units, Prefixes and Symbols

In the International System (SI), there are seven basic units (see Table 1)-the building blocks of the entire system. These units, with two supplementary units (see Table 2) and a series of approved prefixes (see Table 3), provide a logical base ten system from which other units may be derived.

TABEL 1

SI Base Units

Quantity	Unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	amphere	A
thermodynamic temperature	Kelvin*	K
amount of substance	mole	mol
luminous intensity	candela	cd

*The basic unit of temperature is the Kelvin, but for practical applications the degree Celsius (°C) is used.

TABLE 2

Supplementary Units

Quantity	Unit	Symbol
plane angle	radian	rad
solid angle	steradian	sr

Since the metric system is a decimal system, all multiples and submultiples of a unit involve powers of ten. Each multiple and submultiple is designated by a prefix which is used to indicate its value. Table 3 gives the full range of SI prefixes to be used as a reference by the teacher and does not imply that teachers should expect elementary children to be familiar with all of them. In fact, prefixes in the range milli to kilo should be sufficient to illustrate the logical structure of the metric system.

TABLE 3

SI Prefixes

Multiplication Factors	Prefixes	Symbol
$1\,000\,000\,000\,000\,000\,000 = 10^{18}$	exa	E
$1\,000\,000\,000\,000\,000 = 10^{15}$	peta	P
$1\,000\,000\,000\,000 = 10^{12}$	tera	T
$1\,000\,000\,000 = 10^{9}$	giga	G
$1\,000\,000 = 10^{6}$	mega	M
$1\,000 = 10^{3}$	kilo	k
$100 = 10^{2}$	hecto	h
$10 = 10^{1}$	deka	da
$0.1 = 10^{-1}$	deci	d
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000\,001 = 10^{-6}$	micro	M
$0.000\,000\,001 = 10^{-9}$	nano	n
$0.000\,000\,000\,001 = 10^{-12}$	pico	p
$0.000\,000\,000\,000\,001 = 10^{-15}$	femto	f
$0.000\,000\,000\,000\,000\,001 = 10^{-18}$	atto	a

Other "derived units" are formed by multiplying and/or dividing base units without involving any numeric factor other than one (1). Some of the more common derived units are given in Table 4.

TABLE 4

Examples of SI Derived Units
(expressed in terms of base units)

Quantity	SI Unit	
	Name	Symbol
area	square metre	m^2
volume	cubic metre	m^3
speed, velocity	metre per second	m/s
acceleration	metre per second squared	m/s^2
wave number	1 per metre	m^{-1}
density, mass density	kilogram per cubic metre	kg/m^3
current density	ampere per square metre	A/m^2
magnetic field strength	ampere per metre	A/m
concentration (of amount of substance)	mole per cubic metre	mol/m^3
activity (radioactive)	1 per second	s^{-1}
specific volume	cubic metre per kilogram	m^3/kg
luminance	candela per square metre	cd/m^2

Formal definitions of the preceding units are stated in technical language and can be found in NBS Special Publication 330 entitled **The International System of Units (SI).**

Certain other units, although not officially called SI units, have been accepted for use in conjunction with the system. These are summarized in Table 5.

TABLE 5

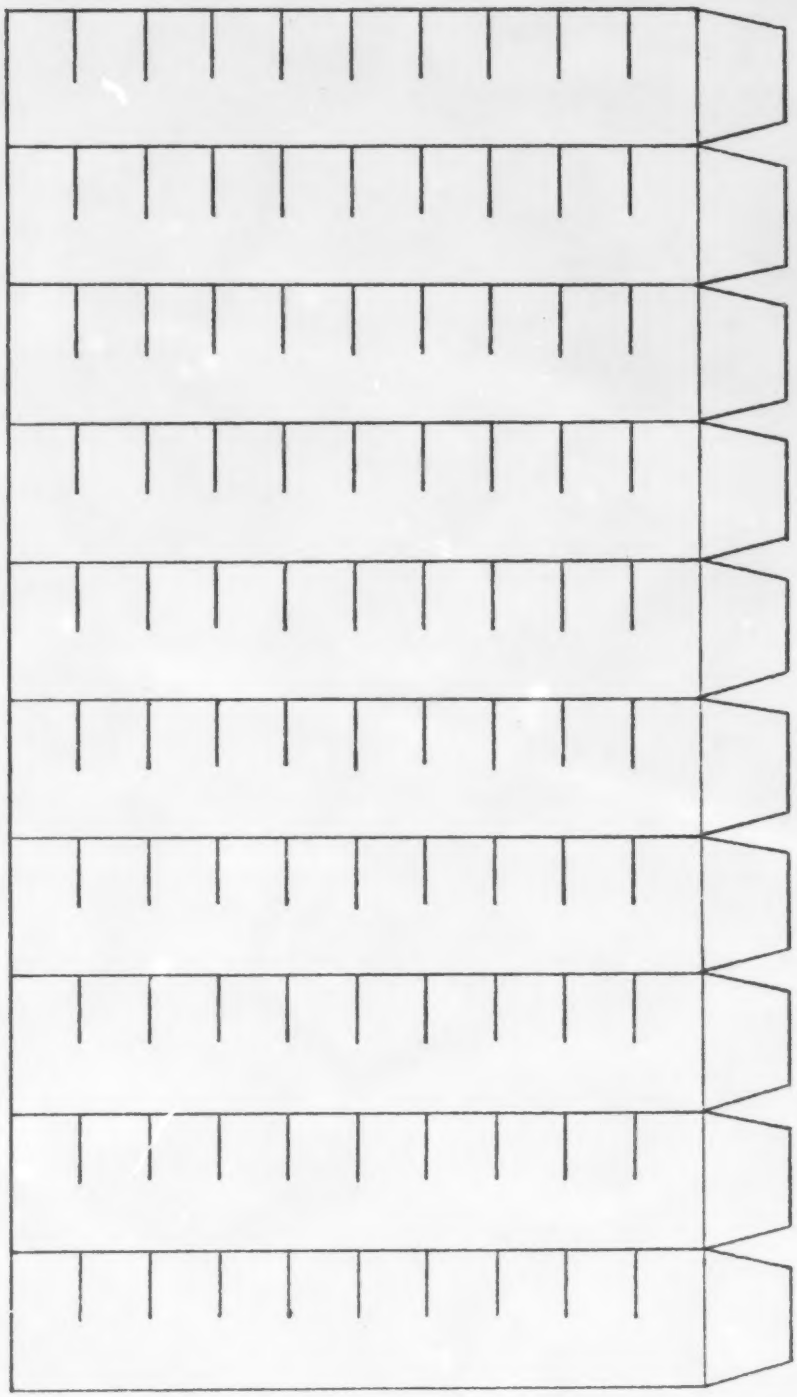
Units in Use with the International System

Name	Symbol	Value in SI
minute	min	1 min = 60 s
hour	h	1 h = 60 min
day	d	1 d = 24 h
degree	°	$1° = (\pi/180)$ rad
minute	'	$1' = (1/60)°$
second	''	$1'' = (1/60)'$
litre	*l*	$1\,l = 1\ dm^3$
tonne	t	1 t = 1000 kg

APPENDIX F

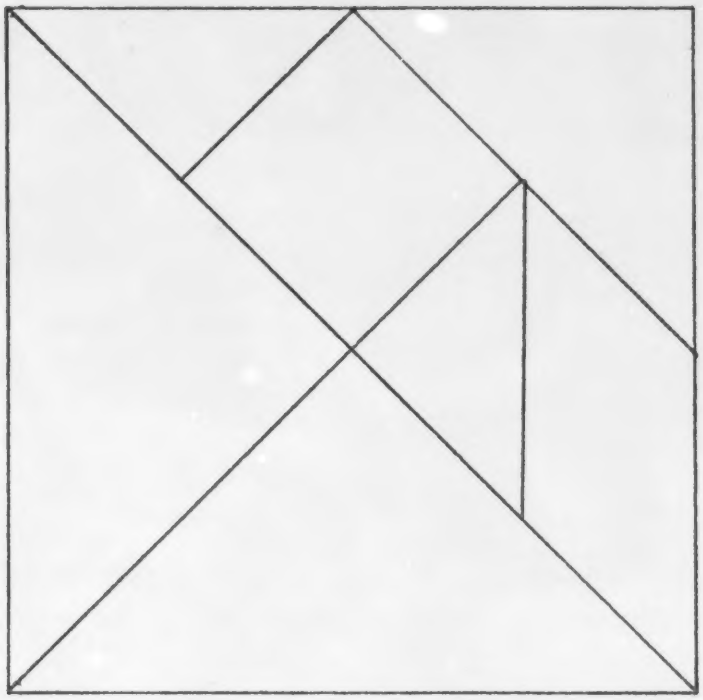
This appendix contains several patterns for use in constructing measuring devices.

Pattern for one metre ruler marked in centimetres.

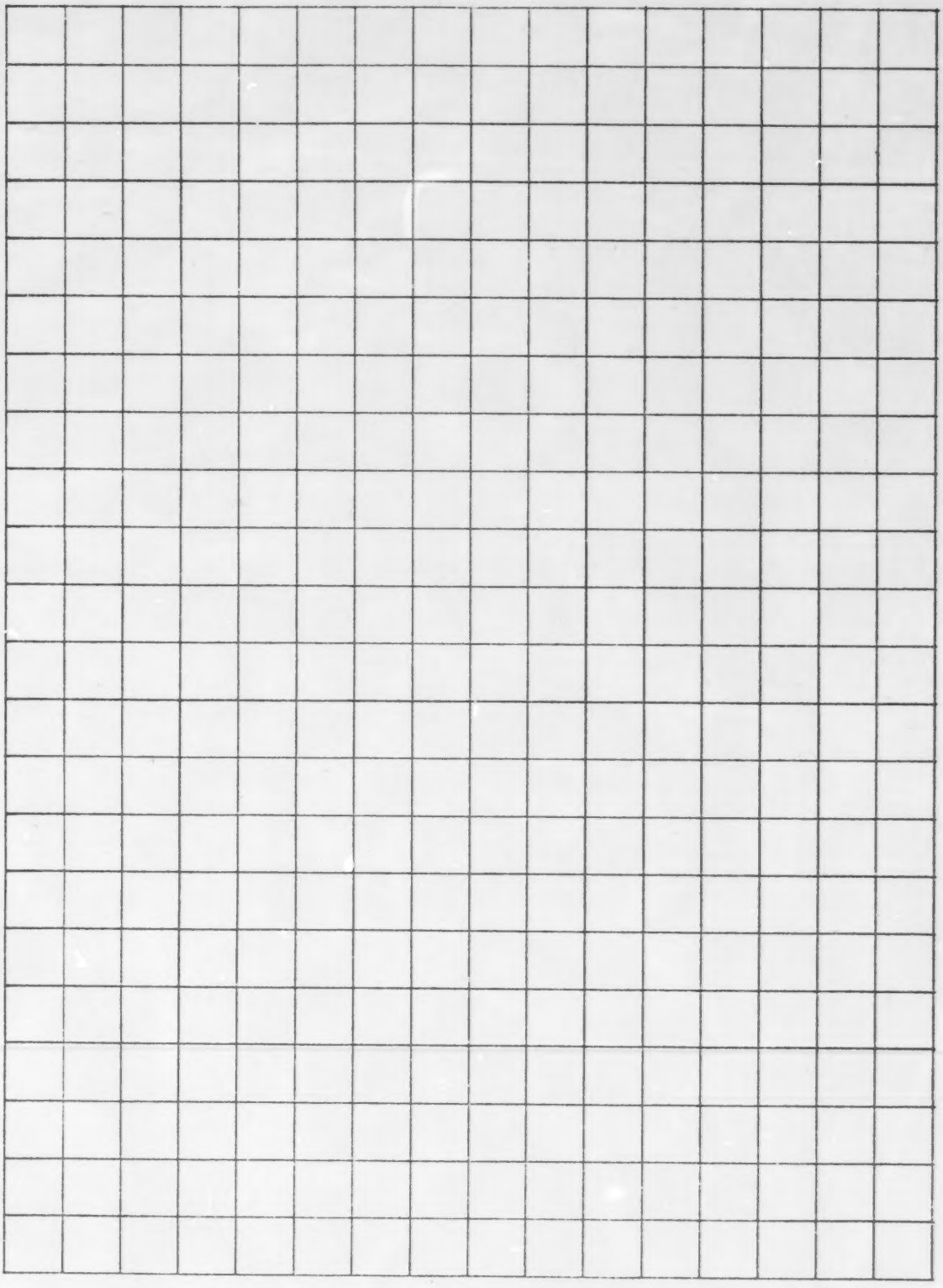


TANGRAM PUZZLE

Below is a pattern for a tangram puzzle. Duplicate the pattern, glue to tagboard, and cut out the seven pieces.

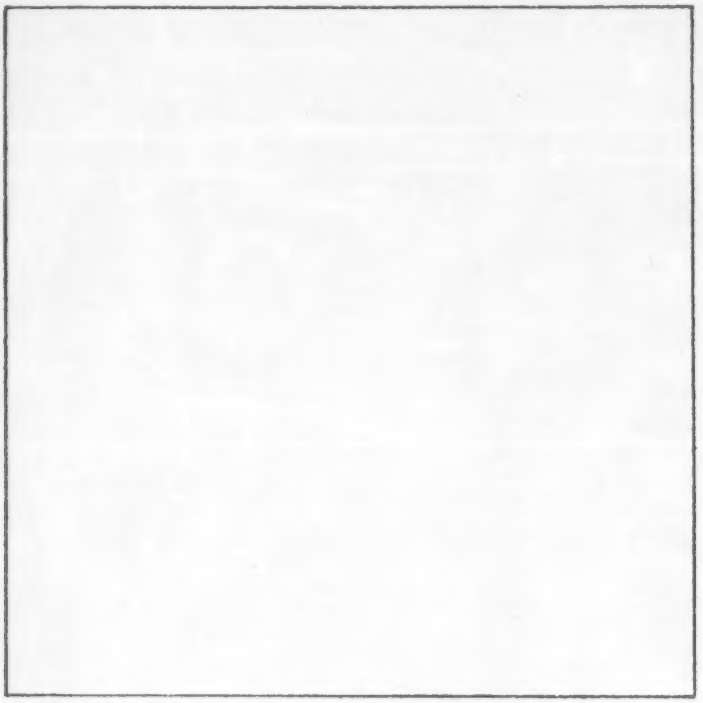


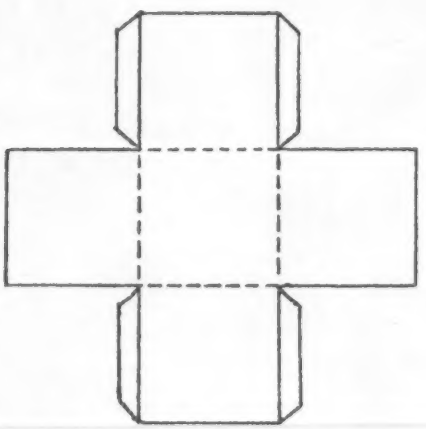
SQUARE CENTIMETRE GRID



THE LITRE BOX

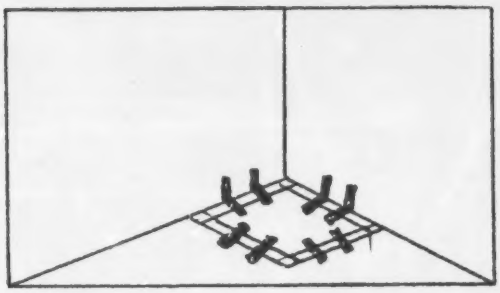
Use the square decimetre below to trace a pattern like the following on a poster board.



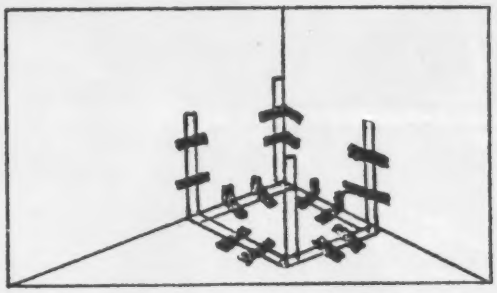


Cut out and fold up to make a box. Tape the edges together with masking tape. For added strength, wrap around the sides several times.

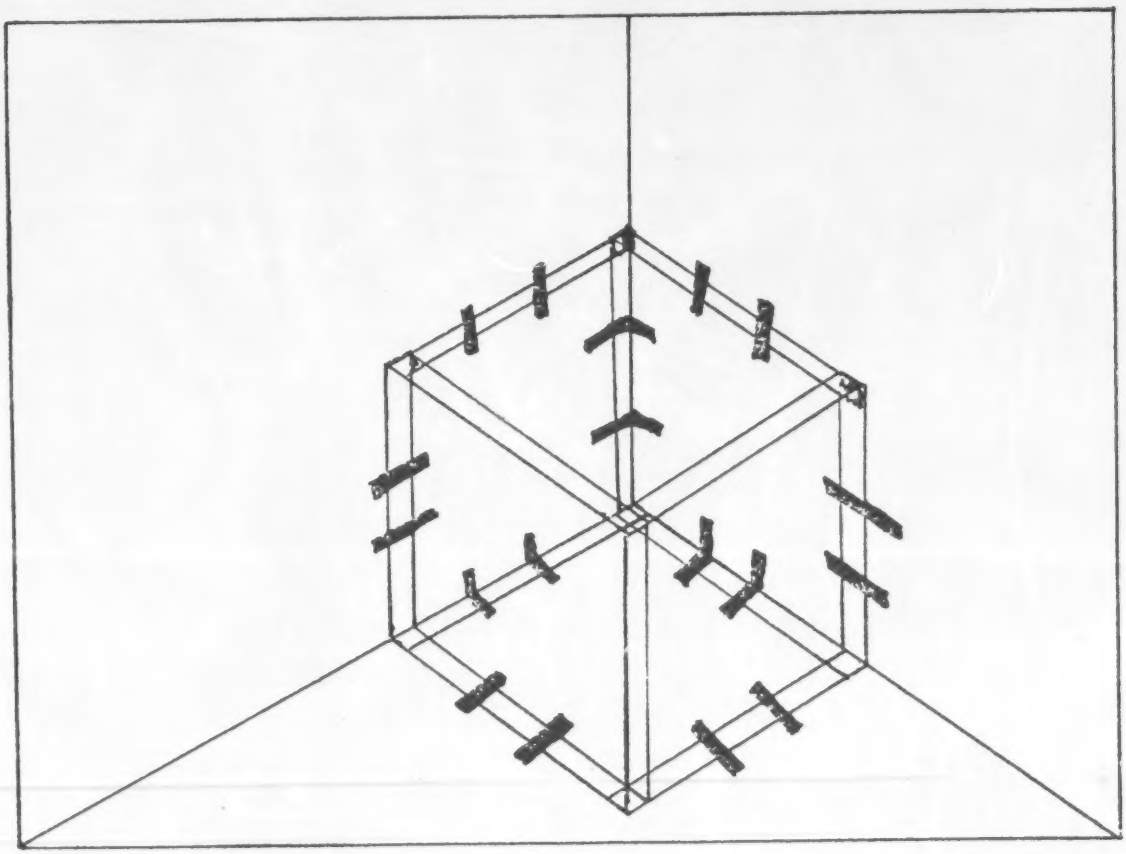
MODEL OF A CUBIC METRE



1. Tape 4 metre sticks to the floor in the corner of the room.

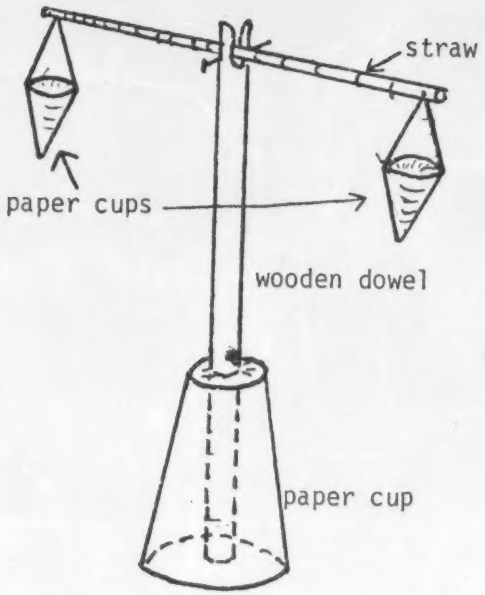


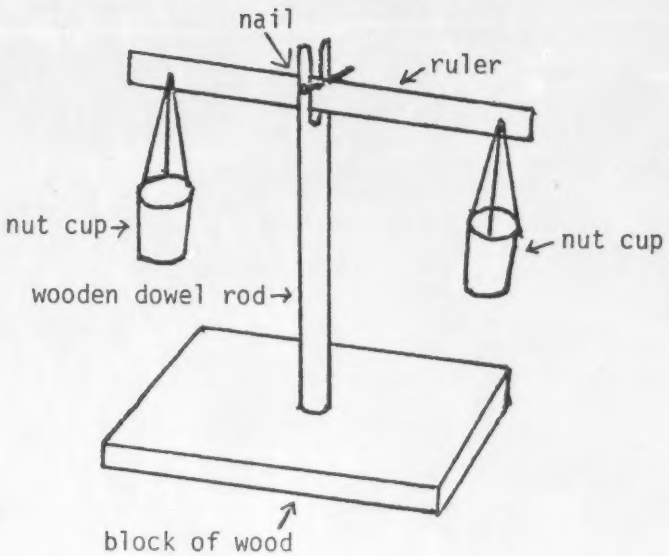
2. Add 4 metre sticks to form the sides (height).



3. Add 4 more metre sticks to form top.

MODELS OF HOMEMADE BALANCE SCALES





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